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Many-Screen Viewing: Collaborative Consumption of  
Television Media Across Multiple Devices

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Thesis submitted to the University of Nottingham for  
the degree of Doctor of Philosophy

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# Abstract

The landscape of television is changing. Modern Internet enabled sets are now capable computing devices offering new forms of connectivity and interaction to viewers. One development enabled by this transition is the distribution of auxiliary content to a portable computing device, such as a mobile phone or tablet, working in concert with the television. These configurations are enabled by second screen applications that provide relevant content in synchronisation with the programme on a nearby television set. This thesis extends the notion of second screen to arrangements that incorporate multiple mobile devices working with the television, utilised by collocated groups of participants. Herein these arrangements are referred to as 'many-screen' television.

Two many-screen applications were developed for the augmentation of sports programming in preparation of this thesis; the Olympic Companion and MarathOn Multiscreen Applications. Both of these applications were informed by background literature on second screen television and wider issues in HCI multiscreen research. In addition, the design of both applications was inspired by the needs of traditional and online broadcasters, through an internship with BBC Research and Development and involvement in a YouTube sponsored project. Both the applications were evaluated by

collocated groups of users in formative user studies. These studies centred on how users share and organise what to watch, incorporate activity within the traditionally passive television viewing experience and the integration of user-generated video content in a many-screen system.

The primary contribution of this thesis is a series of industry validated guidelines for the design of many-screen applications. The guidelines highlight issues around user awareness devices, content and other user's actions, the balance between communal and private viewing and the appropriation of user-generated content in many-screen watching.

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Each of the studies in this thesis involved user research and required participants to give up their time and offer their expertise and opinions. Thanks to the 60 users, 12 pilot participants and 6 experts who took part.

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# Contents

CHAPTER ONE: Introduction.....	1
Second screens.....	3
Media multitasking.....	3
Second screen applications.....	5
Motivations.....	6
Thesis statement.....	8
Many-screen television.....	9
User-generated video.....	10
Leaning backward and forward.....	11
Methods and approach.....	12
Lab observation.....	17
Findings analysis.....	18
Contribution.....	19
Research contribution.....	21
Thesis outline.....	21
 CHAPTER TWO: Review of Existing Literature.....	25
Interactive television.....	26
Second screen television.....	28
Second screen television.....	29
Control.....	30
Share.....	32
Enrich.....	33
Transfer content.....	34
Second screens in the television industry.....	35
Sports applications.....	37
Dual screen television discussion.....	38
Multiscreen hci.....	40
Multiscreen in computer supported cooperative work.....	40
Single display groupware and user feedback.....	41

Display ecologies.....	42
Hci in the home .....	44
Television watching.....	46
Mobile television .....	46
User-generated video content .....	48
Sport and user-generated video .....	52
Final discussions .....	53
Conclusion.....	56
 CHAPTER THREE: Designing The Olympic Companion Application .....	57
Introduction .....	57
Industry engagement .....	58
The british broadcasting corporation .....	59
Bbc research and development .....	61
Internship with bbc r&d .....	62
Existing bbc applications and platforms .....	63
Public applications.....	63
Antiques roadshow .....	63
Gory games .....	65
The voice uk.....	65
Research and internal pilot applications .....	67
Autumnwatch .....	67
Jigsaw .....	68
Secret fortune.....	69
Universal control platform .....	70
Application focus .....	71
Sports programming .....	71
Application requirements.....	72
The olympics.....	74
Application design .....	75
Prototype version.....	75
User study enhancements .....	78
Revised architecture .....	78
Application walkthrough .....	80
Application content.....	86
Application usage scenario .....	87
Conclusion.....	89
 CHAPTER FOUR: Studying The Olympic Companion Application .....	91
Introduction .....	91
Study objectives .....	92
Study method .....	93
Participants .....	94
Lab layout and apparatus.....	96
Design .....	97
Study procedure.....	98
Data analysis .....	99

Findings .....	101
General opinion and prior experience .....	102
Opinions on statistics feeds .....	104
Ecology, and sociality and the arrangement of devices .....	105
The role of the television.....	106
Headphones and sound .....	107
Focus and sharing .....	108
Requesting and showing.....	108
Using the tablet to queue up content for the big screen.....	111
Watching alone.....	111
Content control.....	111
Liveness.....	112
Chapter discussion.....	113
Study implications.....	114
Study objective 1 .....	114
Study objective 2.....	114
Study objective 3.....	116
Study limitations .....	116
Conclusion.....	117
 CHAPTER FIVE: Designing The Marathon Multiscreen Application.....	119
Introduction .....	119
Runspotrun project .....	120
Personal investment in the project .....	121
Runspotrun mobile application .....	122
Evaluating the runspotrun mobile application .....	123
Runspotrun as a multiscreen case study .....	126
The sociality of spectating .....	127
Application description.....	128
Application functionality .....	130
Application content.....	133
Application walkthrough .....	134
Application first mode .....	134
Application second mode .....	138
Application usage scenario .....	143
Conclusion.....	146
 CHAPTER SIX: Studying Marathon Multiscreen .....	147
Introduction .....	147
Study aims and objectives .....	148
Study method .....	150
Participants .....	151
Lab layout and apparatus.....	153
Study procedure and design.....	154
Data analysis .....	157
Findings .....	159
General opinions .....	160



Coordination of viewing .....	162
Working alone and together .....	163
Television and control .....	165
Inter-device relationship .....	166
Content control.....	167
Amateur and professional video.....	168
Chapter discussion.....	169
Study implications.....	170
Study objective 1 .....	170
Study objective 2.....	171
Study objective 3.....	172
Study limitations .....	173
Conclusion.....	173
 CHAPTER SEVEN: Discussion & Design Guidelines .....	175
Introduction .....	175
Application summary .....	176
Design guidelines for multiscreen television applications .....	179
Parallel viewing .....	179
Sound implications .....	181
Viewing across different activities.....	182
Scheduling, queuing and sharing .....	184
User awareness of the ecology and respect the television .....	186
Acknowledge liveness and the impact of spoilers.....	188
Complexity of gesture and attention.....	190
Professional and amateur.....	191
Public and private and avoiding embarrassment.....	193
Practitioner validation of guidelines .....	194
Aims .....	195
Method .....	195
Interview discussion points.....	197
Practitioner reflections.....	201
Discussion point 1: parallel viewing and awareness of the device	
Ecology .....	201
Discussion point 2: scheduling queuing, sharing and liveness	
With a device ecology.....	203
Discussion point 3: integration of amateur content into television	
Programming.....	206
Discussion point 4: implications of integrating lean-forward and backward	
Activities in television interaction .....	207
Multiscreen futures .....	208
Conclusion.....	209
 CHAPTER EIGHT: Conclusion.....	211
Introduction .....	211
Guideline synthesis and thesis questions.....	213
Question 1: sharing and scheduling .....	219
Scheduling.....	221

Question 2: user-generated content .....	222
Public and private viewing .....	223
Question 3: leaning forward and backward .....	223
Limitations .....	225
Ecological validity .....	225
Future work .....	226
In the wild evaluation .....	226
Final reflections .....	228
References .....	231
 APPENDIX A: Platform Infrastructure .....	 247
Components .....	247
Functionality .....	248
Television functionality .....	250
Application functionality .....	250
Design patterns .....	252
Platform messaging protocol .....	256
Modules .....	259
 APPENDIX B: Channel Schemas .....	 263
Olympic companion application .....	263
Marathon multiscreen mode 1 .....	265



# List of Figures

Image 1 - 1 Media meshing activities conducted while watching TV (Office of Communication, 2013b) .....	4
Image 1 - 2 Overview of thesis research process.....	15
Image 2 - 1 Second screen EPG (Cruickshank et al., 2007) .....	31
Image 2 - 2 'The Million Pound Drop' second screen application (channel 4, 2014).....	36
Image 2 - 3 The 'Walking Dead' kill counter application.....	37
Image 2 - 4 YouTube video genres (cha et al., 2007) .....	51
Image 3 - 1 The Antiques Roadshow Application (Williams, 2013) .....	64
Image 3 - 2 Gory Games Application (Gory Games, 2014).....	65
Image 3 - 3 The Voice UK Application (The Voice UK, 2014) .....	66
Image 3 - 4 The Jigsaw Application (Courtesy of BBC R&D) .....	68
Image 3 - 5 The Universal Control Dalek (Woolard [still from embedded video], 2011).....	71
Image 3 - 6 Olympic Companion System Architecture Outline .....	80
Image 3 - 7 The Olympics tablet application upon launch .....	81
Image 3 - 8 the playback dialog box.....	82
Table 3 - 1 Commence playback dialog options .....	83
Image 3 - 9 Tablet Video Playback .....	84
Image 3 - 10 Stats and Info dialog.....	84
Image 3 - 11 Stats and Info displayed on the tablet.....	85
Image 3 - 12 the remote control application .....	86
Image 3 - 13 Programming schedule for Olympic Companion Study.....	87
Table 4 - 1 Study groups and their pre-existing experience .....	95
Image 4 - 1 Olympic Companion study lab layout .....	97
Image 4 - 2 Data playback and analysis tool .....	100
Image 4 - 3 Data analysis theme organisation .....	101

Table 4 – 2 Olympic Companion Study Codes Overview.....	102
Image 4 - 4 Participants using headphones on one ear .....	108
Image 4 - 5 Leaning in to see the tablet.....	109
Image 4 - 6 Holding out the tablet .....	110
Image 4 - 7 Leaning in and interacting with the tablet .....	110
Image 4 - 8 Leaning in to see the tablet.....	110
Image 4 - 9 Using the tablet as a preview screen on the coffee table .....	111
Image 5 - 1 The RunSpotRun mobile application.....	123
Image 5 - 2 MarathOn Multiscreen playing back video in the first mode.....	130
Image 5 - 3 MarathOn Multiscreen showing runner video map.....	132
Image 5 - 4 The MarathOn Multiscreen Application first mode upon launch ...	134
Image 5 - 5 Selecting a professional feed, video or facts and figures .....	135
Image 5 - 6 Selecting a playback location and start playhead .....	135
Image 5 - 7 MarathOn Multiscreen with television controls .....	136
Image 5 - 8 Selecting an amateur video, device and playback location .....	137
Image 5 - 9 MarathOn Multiscreen video playback on tablet.....	137
Image 5 - 10 MarathOn Multiscreen facts and figures display .....	138
Image 5 - 11 The application upon launch in its second mode of operation...	139
Image 5 - 12 Runner map interface .....	139
Image 5 - 13 Runner map select video .....	140
Image 5 - 14 Runner list interface .....	140
Image 5 - 15 Play event dialog box.....	141
Image 5 - 16 Playback video with tag Jason button.....	141
Image 5 - 17 new tag confirmation message .....	142
Image 5 - 18 television tagging interface .....	142
Image 5 - 19 Playlist .....	143
Table 6 - 1 Study Participants .....	152
Image 6 - 1 Participants using MarathOn Multiscreen .....	154
Image 6 - 2 Study Planning .....	155
Image 6 - 3 Data Analysis Tool.....	157
Image 6 - 4 Adding Comments in the analysis tool.....	158
Table 6 – 2 Summary of MarathOn Multiscreen Codes .....	160
Image 6 - 5 Participants working together and alone .....	164
Image 6 - 6 Participants all working together .....	164
Table 6 - 3 Tags and duplicated tags by groups .....	167
Table 7 - 1 Application functionality .....	177
Table 7 - 2 Industry Interview Participants .....	196
Table 7 - 3 Discussion Point 1 .....	198
Table 7 - 4 Discussion Point 2 .....	199
Table 7 - 5 Discussion point 3 .....	200
Table 7 - 6 Discussion point 4 .....	201
Table 8 - 1 Research Questions and the associated guidelines and reflections .....	218
Image A - 1 Multiscreen platform architecture overview .....	256
Table A - 1 Multiscreen platform message types.....	259
Table A - 2 Multiscreen platform messages .....	262

# CHAPTER ONE

## *Introduction*

The television is a cornerstone of everyday life. As an object of communication that mediates and guides our political and social discourse, the medium has woven itself “profoundly and intimately into the fabric of our daily lives” (Silverstone, 2004). The enabling technologies that support user interaction with the television have evolved alongside broadcast traditions, and viewer understanding and trust. For example, the rise of the VCR (video cassette recorder), DVD (digital versatile disc) player and PVR (personal video recorder) has been followed by Internet streaming and downloading as means of storing programmes and organising viewing (Barkhuus & Brown, 2009). Each of these innovations has allowed viewers increasing agency in their viewing habits, changing the way programming is scheduled, shared and otherwise consumed, enabling interactions and experiences not possible with conventional linear broadcasting alone.

This thesis is principally concerned with one such innovation, the distribution of interaction and broadcast programming to different devices working in concert with the television. There is a growing trend for employing an additional screen when watching the television, augmenting the traditional

TV screen with other devices including, laptops, tablets and smartphones. The rise of portable computer use in the living room and its interaction with television viewing has been noted by academics working at the intersection of human computer interaction and television (Courtois & D’Heer, 2012), industry professionals (Sowerby, 2012) and regulatory bodies (Office of Communication 2013b). These authors have variously attempted to rationalise these new cross device viewing behaviours, revealing how they empower the user to "control, transfer, enrich, and share" (Cesar et al., 2008) television content. Much of this work has analysed the ad-hoc configuration of devices by users to fuse social networking with viewing, or the development of second screen companion applications.

Other innovations in television research and usage include; the distribution of programmes and broadcast to mobile devices, improvements to electronic programme guides, such as search and recommendation, and the integration of user-generated content in programming. Recent years have seen a dramatic increase in the creation of crowd-sourced amateur video footage, along with tools and platforms that enable its distribution and use. Everyone is now capable of being a videographer and most people will carry a video camera (mobile telephone) with them, allowing them to record fleeting events and document their lives at any time. These forms of video and Internet sharing are blurring a line, calling “traditional notions of the ‘amateur’ and ‘professional’ into question” (Engström et al., 2012).

The main foci of this thesis will be to extend these notions, developing an understanding of experiences that take place across a number of companion devices, integrating a second, third and fourth screen and the television, in the collocated, social environment that is characteristic of viewing. Throughout this dissertation these configurations of devices are referred to as ‘many-screen’ or multiscreen television. In addition, the ramifications of the confluence of many-screen television and user-generated video content will be investigated.

This chapter, begins by outlining the problem space, defining media multitasking and an introduction to second screen companion applications. This is followed by the thesis statement and motivations that ground the

research effort conducted in completion of this dissertation. The methodological perspective taken in development of the research is considered and the contributions of the thesis are outlined. The chapter concludes with an outline summary of each subsequent chapter of the thesis.

## SECOND SCREENS

### Media Multitasking

In a recent report by the broadcast regulator in the United Kingdom, Ofcom (Office of Communication), an increase in the uptake of media multitasking while watching the TV is noted. The report states that in 2012 almost 70% of the sample population were engaged with other media while viewing, these behaviours included use of mobile and landline telephones, surfing the Internet and playing video games (Office of Communication, 2013a). In a further report for the same period that also took into consideration device ownership, it was reported that the proportion of media multitaskers was 80% of tablet owners (Office of Communication, 2013b). The report divides the activities of media multitasking into two. First, activities that are unrelated to the content being watched on the television, such as checking work emails are referred to as “media stacking”. Secondly, “media meshing” refers to activities that are directly related to what is happening on the television screen. Such activities might include, looking up actor names, posting tweets or other social media updates about the programme, or playing along with a quiz show.

36% of respondents to the Ofcom ‘Communications Market’ report agreed that they engaged in media meshing activities (Office of Communication, 2013b). As shown by Image 1-1 the majority of this activity involved users interacting with other devices and programming in ad-hoc ways, using their mobile phones to text and call other viewers, searching the Internet for further information and programme content, or posting to social networking sites. Authors from academia have also responded to this trend and investigated the interaction of television and social media (Doughty et al., 2012 and Lochrie & Coulton 2012), studying the spread and impact of posts



and tweets. The proliferation of ad-hoc behaviours with smart devices while viewing contrasts with usage of dedicated companion applications targeting individual programmes or that aggregate a user's viewing, where usage rates are only between 3 and 4%.

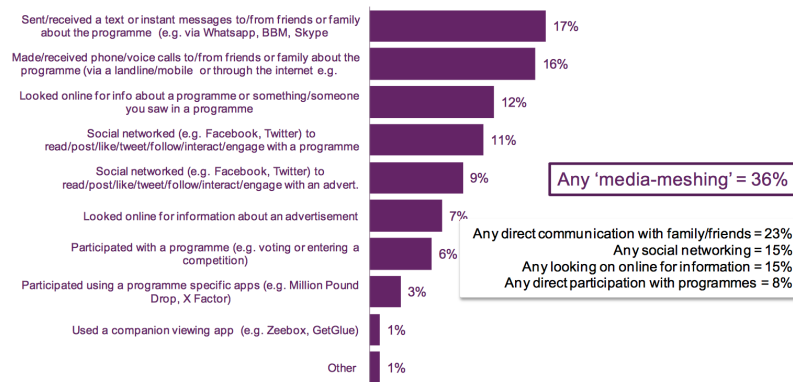


Image 1 - 1 Media meshing activities conducted while watching TV (Office of Communication, 2013b)

While these trends illustrate a stronger user uptake for ad-hoc television configurations, it could be posited that the design of bespoke companion applications remains of particular interest to the broadcast industry. For broadcast organisations that operate in the commercial arena, the development of companion applications affords opportunities to maintain viewer focus, ensuring attention is paid to advertisements and a better knowledge of viewer interests and demographics can be obtained. However, other benefits are considerably more wholesome and of more relevance to public service broadcasters, enabling programme makers to further engage viewers in additional content, and maintaining relevance to a broader subset of viewers. The development of the two studies that form the empirical contribution of this thesis were inspired by the needs of the broadcast industry, a key stakeholder in the development of second screen applications. The application that formed the core of the first study discussed within, the Olympic Companion Application, was developed during an internship conducted at the BBC's Research and Development department.

## Second screen applications

Dual screen applications, also referred to as second screen or companion applications, are the current mainstay of multiscreen television research and industry interest at the current time. These applications are designed to augment the viewing experience with additional information, opportunities to interact with and share television programming across the Internet. An account of the opportunities afforded by second screen television is provided by Cesar et al. (2008) that spans both designed experiences and ad-hoc configurations. Cesar et al. describe second screen television as allowing users to “control, enrich, share and transfer television content”.

Work that focuses on the explicit design of second screen companion applications that bring additional interactive functionality to television programmes, contrasts with research that collates and analyses media stacking behaviours with mobile devices and social networking services. For example, enriching companion applications offer content to deepen a viewer’s knowledge of characters (Nandakumar & Murray 2014), supplementary web media about the themes, topics or the actors in a programme (Basapur et al., 2011 and Basapur et al., 2012) and new learning opportunities with television content (Fallahkhair, 2005). Personalised and efficient television control systems are enabled through and to access Electronic Programme Guides (EPGs) (Cruickshank et al., 2007 and Park et al., 2006).

This academic research has been mirrored by developments in the broadcast industry where a growing number of second screen applications are being commercially deployed to sit alongside programming. For example in the United Kingdom ‘The Million Pound Drop’ (Channel 4, 2013) and ‘Antiques Roadshow’ (BBC, 2013) both offer apps that allow viewers to play along with on screen events and questions.

In spite of this growing area of literature and innovation, little has been reported about how we might understand and design for situations in which groups of viewers gather around a television and interact with multiple

second screens. This is remiss as HCI work conducted in the home highlights the importance of social practice and group dynamics (Hindus, 1999), in addition to the important place the television plays in the domestic setting (Barkhuus & Brown, 2009).

This thesis centres on many-screen applications specific to the genre of sports programming. Several publicly deployed applications have been designed to augment the experience of watching sports events and championships (SkySports, 2013 and Patel, 2012). Academic research on companion applications has investigated sports programming and the interplay between user-generated content, professional broadcasting and the experience of being at an event (Dezfuli & Günther, 2013).

A more detailed treatise of dual screen applications is provided in Chapter Two, Review of Existing Literature. Additionally, specific details of companion applications developed by the BBC, both for research and public deployment, are discussed in Chapter Three, Designing the Olympic Companion Application.

## MOTIVATIONS

The preceding section has introduced concepts that inform the distribution of television programming and associated content to auxiliary devices. This direction is set within an evolving landscape of interaction opportunities that are being presented by broadcast programming, the television set, and the interfaces that sit between them and the user.

The use of second screens is acknowledged by a range of authors from academia and beyond as a rising phenomena worthy of further investigation. However, to date limited work has been conducted that considers user perspectives on the consumption of television programming across multiple screens (Courtois & D’heer, 2012). The research work conducted by this thesis will primarily make use of tablet computers which are seen as readily “accessible, tangible and continually web enabled” devices (Courtois & D’heer, 2012). The lightweight interaction offered by tablets combined with

the television offer new opportunities for engagement with programming. This thesis emphasises the integration of television viewing behaviour with second screens in a collocated environment. This approach is designed to uncover the social behaviour of viewing with multiple display devices, such as public and private viewing, and user control of content developed by the mass media (D'heer et al., 2012). This poses questions as to the impact of the availability of second screen devices to users. For example, does giving one tablet to each participant engender a different usage pattern to a limited resource that is shared across an interacting group.

Interactions with social television systems, such as the ones discussed in this thesis are best suited to the genres of news, sports, quizzes and soaps (Geerts et al., 2008). The overarching narratives offered by sports was considered to be more appropriate to the collocated emphasis of the thesis. Viewers of sports programming have been shown to be engaged with the content outside of the bounds of the programming, feel personal investment in its outcomes and engage in search activities to find out more about the events and history of the team or competition (Gantz et al., 2010). In addition, this genre choice allowed for a deeper industry engagement with the BBC during the internship discussed in Chapter Three.

Furthermore, television viewing has traditionally been taken as a 'lean-back' activity (Nielson, 2008) where viewers are passive interactions with content. The integration of second screen viewing enables users to transition to 'lean-forward' interactors with programming content. For example, playing along with a quiz show or selecting camera angles from which to watch highlights. The combination of these characteristics enables new use cases for television viewing and user configurations while watching.

As part of this investigation into the nature of many-screen television and the collocated environment this thesis will also draw conclusions on the integration of another major movement in the development of television, the combination of user-generated content. As stated above, much of the work into second screen television viewing has analysed user creation of social

networking statuses and other intertext related to the programming they are watching. Other literature, which investigates sports spectating and the experience of being at an event, points towards the use of video as enhancing the spectating experience (Jaccuci et al., 2006 and Flintham et al., 2015). That is not to say that other forms of user-generated content are not applicable to sports broadcasting, however, attention to this genre affords opportunities to consider an under explored set of interactive challenges. While a technical implementation for the integration of second screen viewing and professional and amateur video is proposed by Dezfuli & Günther (2013) there has yet to be a study that evaluates the interaction of these paradigms with users.

The first research investigation documented by this thesis, the Olympic Companion Application, is concerned with the interests of the professional broadcaster and the development of many-screen applications to deliver sports programming from the Olympic Games, which engaged viewers with programming across simultaneously occurring sporting events and auxiliary information about results, athletes backgrounds and other intertextual content. The second investigation illustrates a democratised, and further reaching future television application that integrates professional and amateur content. The MarathOn Multiscreen Application incorporates mechanisms by which to organise, consume and share user-generated video content, alongside watching more traditional television.

## THESIS STATEMENT

The above motivation shows a research impetus for investigating television interactions that take place across multiple display devices by a collocated interacting group of users. The following aim defines the research focus of this thesis:

**The synthesis of industrially informed and verified guidelines that support the design of ‘many-screen’ television applications that allow synchronous interaction across multiple display devices. The guidelines incorporate collocated viewer requirements in respect of both watching and organising**

**a schedule of professional sports programming and user-generated video content.**

This overall aim is divided into three research questions that further inform the development of the research conducted as part of this thesis, these questions centre on the social sharing of television content across many-screens, the integration of lean-forward tasks into television watching and the confluence of many-screen viewing and user-generated video.

Many-Screen television

*How is content shared and scheduled by users interacting with a many-screen television experience, and how does the integration of additional display devices alter the traditional single or dual screen viewing environment?*

The notions of second screen television were introduced in the prior sections and will be explored in detail in the literature review that follows this chapter. The extant literature reveals a growing interest in exploring interaction with television content that extends beyond the TV set and includes auxiliary devices. Contributing authors such as Cruickshank et al. (2007) and Basapur et al. (2011) report an impact on the sharing and control of television programming when second screen applications are deployed in a collocated social environment. Authors who report on the social nature of traditional television watching in the domestic environment, through ethnographic methodologies, make the case that a thorough investigation of understanding interactive practices in the home will involve the exploration of the social situations within which users inhabit (O'Brien et al 1999). Despite this impetus, studies and applications developed to discuss directly the social experience of watching television in the collocated environment are not as evident in second screen and companion literature.

Placing second screen interaction in a collocated environment poses the question of whether the auxiliary device should be a limited or abundant resource. While the communications market report from Ofcom (Office of

Communications, 2013b) suggests that only around 10% of UK households have access to more than one tablet device, it also notes an upward trend in the number and variety of computing devices available to users in the home. For example, should a tablet application augmenting a television programme, be available on a single tablet device shared between several users, or is a separate device available to each viewer. This research question will seek to explore how configurations of multiple display devices alter viewing from watching the television as a standalone display device and interaction with a single tablet in a collocated environment. When different configurations of tablet devices available to users, is there an impact in the way content is shared between users and the sociality of viewing when more tablets are available. In addition, does the introduction of more tablets affect the way in which viewers organise their viewing. The process of selecting what to watch and when to watch it is social one, balancing different viewer's preferences across a group (Taylor & Harper, 2003), how do different configurations of devices affect what content users watch and on what devices?

This thesis reports the development and evaluation - two many-screen applications. The first of these applications, the Olympic Companion Application, was primarily evaluated to test the effect of multiple configurations of devices while watching highlights of the London Olympic games from 2012. The application made an evolving schedule of content available to users, which ensured that exciting moments of the games were broadcast simultaneously, forcing users to make viewing decisions about what to watch, when and on what device. The Olympic Companion Application is discussed in detail in chapters Three and Four.

### User-generated Video

*How do users appropriate user-generated video content while watching across multiple display devices, what methods are employed to sort and organise valuable footage from a wider corpus of video? In addition, what factors influence user opinion on the value of user-generated video, how does this differ from professional shot and produced programming?*

HCI literature on sports spectating has included studies on the generation of user-generated video content and the interplay of the amateur footage and professional content, this is symptomatic of a wider interest in user-generated content across HCI. Extant dual screen literature has primarily focused on the integration of social media posts simultaneously while viewing (e.g. Doughty et al., 2012). Findings relevant to this research question however, will describe the integration of user-generated video footage. User opinion on the experience of interacting with user-generated video footage will be sought, asking how is value attached to specific items of user-generated content when interacting with a large corpus of video, how does the amateur footage interplay with professional content, and how are the types of content appropriated across the multiple display devices available to users.

The second study described in this thesis, MarathOn Multiscreen combines a corpus of amateur footage and professionally shot and produced video from a community running event. Some of the footage had been shot by or contained photography of participants who took part in the study. As part of the study schedule users were asked to interact with the video sorting and searching for footage of a specific runner.

### Leaning backward and Forward

*Television viewing that takes place across multiple displays enables 'lean-forward' modalities. What strategies and configurations are adopted by users while engaging with lean-forward task, and how does this vary from 'lean-backward' viewing?*

The first research question investigates the sharing of television content between users with differing numbers of companion devices. This focus enables a shift in television viewing behaviour that engenders collaborative practices with content, coupled with the inclusion of user-generated content, where value is intrinsic to the individual user group. Subsequently user interactions are more active and requires a different type of user engagement. These concepts are developed in this question through the investigation of many-screen television activities that actively engage users in lean-forward



tasks, such as sorting and searching specific content to watch. This approach posits questions on how users best organise themselves and the devices available to them to complete tasks, and what effect does this have on the sociality investigated above.

Traditionally television viewing has been regarded as a passive interactive experience that people engage with to switch off at the end of the day (Taylor & Harper, 2003). Whilst that characterisation is unlikely to change for the most part, the interaction of multiple display devices in television viewing offers user cases in which users transition from lean-backward to lean-forward modalities (Nandakumar & Murray, 2014) and undertake tasks that would be more familiar to the desktop metaphor. Much of the prior research on interaction with multiple display devices from the human computer interaction and computer supported cooperative work disciplines has centred on work related activities, championing productivity and efficiency as key metrics of an interfaces success. This literature is discussed in detail in Chapter Two. Interaction that takes place in the home however, should focus on metrics such as “fun, pleasure, emotion, effect and aesthetics” (Bell et al., 2003). Reflections from this research question will endeavour to further inform prior literature with findings and discussions that focus on many-screen interactions that take place outside of the workplace setting and target interaction that is enjoyable, relaxing and social.

The second application discussed in this thesis, MarathOn Multiscreen, incorporates elements of lean-forward interaction, allowing users to sort and select video footage from a large corpus of user-generated video content, taken during a community running event. This interaction is contrasted by the comparatively lean-backward nature of the Olympic Companion Application, The MarathOn Multiscreen Application is the focus of discussions in chapters Five and Six.

## METHODS AND APPROACH

Human Computer Interaction is interdisciplinary by nature borrowing methodologies, practice and principles from scientific and design disciplines,

examining the interaction of people with digital artefacts (Mackay & Fayard, 1997). In seeking to answer the thesis research questions set out above, the findings of two user studies will be drawn together. The overriding approach of the work conducted in this thesis is the design and user evaluation of prototype applications, designed to reflect future many-screen applications. These prototypes were presented to participants as probes seeking understanding of user behaviour and opinion; these findings were distilled into guidelines for design. The Olympic Companion Application and the MarathOn Multiscreen Application are introduced in the Contributions section below. Given the collaborative nature of the research objectives, focusing on social sharing, content appropriation and viewing modalities the development and analysis of these user studies seek qualitative and inductive answers to these questions. The design of the questions and studies are reflective of the social environment that television watching often takes place in, where viewing practices are “deeply integrated into social networks and activities” (Barkhuus & Brown, 2009).

Traditionally, the development of a digital artefact utilising a user centred design process is commenced with an investigation, or series of investigations, into understanding the context where the interaction is to take place and the practices and goals of tasks to be completed with the system. Methods that guide this process include the use of survey, focus group and user observation (Abrams et al., 2004 and Monk 2000). In this thesis however, the design and development of the prototype applications that were evaluated in the subsequent user studies was inspired by an industry internship and an industry sponsored project. The internship with BBC Research and Development grounded the development of the Olympic Companion Application discussed in detail in Chapter Three. Embedding myself into an industry focused research environment provided opportunity to engage with practitioners who hold a detailed and nuanced understanding of their user base, established through numerous studies into multiscreen television companions. In addition to leveraging this prior user work, the internship enabled an understanding of business needs for these systems and

cutting edge technical approaches to their implementation. The subsequent study conducted as part of this thesis, MarathOn Multiscreen, builds on the design, development and evaluation of the Olympic Companion Application, and the experiences of working on an industry supported project. Funded by a grant from Google, owners of the video sharing site YouTube, the RunSpotRun project established user desire to collaboratively organise and select user-generated footage taken at a community running event, the MarathOn Multiscreen application responds to these needs through the development of a many-screen television application. Descriptions of the MarathOn Multiscreen Application and its interaction with the RunSpotRun project are detailed in Chapter Five.

The findings from the two prototype evaluations are presented as guidelines for design (Zimmerman et al., 2010). The presentation of the results as design guidelines is intended to aid other practitioners developing applications similar to those discussed in this thesis, that involve interactions with television content that take place across multiple display devices. The guidelines draw attention to issues of developing television applications which are utilised in social environments with a flexible number of devices and the integration of user-generated content. In addition to the study findings, the guidelines are informed by existing literature from interactive television, companion applications and other salient works in HCI. The guidelines are presented as textual descriptions, the dissemination of study findings in this way is common practice in HCI and many examples can be found throughout the literature (see Rennick-Egglestone, 2014).

Additionally, the guidelines developed as part of this thesis were evaluated in a group interview conducted with industry practitioners working as part of BBC Research and Development. This process was conducted to further ensure the validity of the guidelines to the broadcast industry.

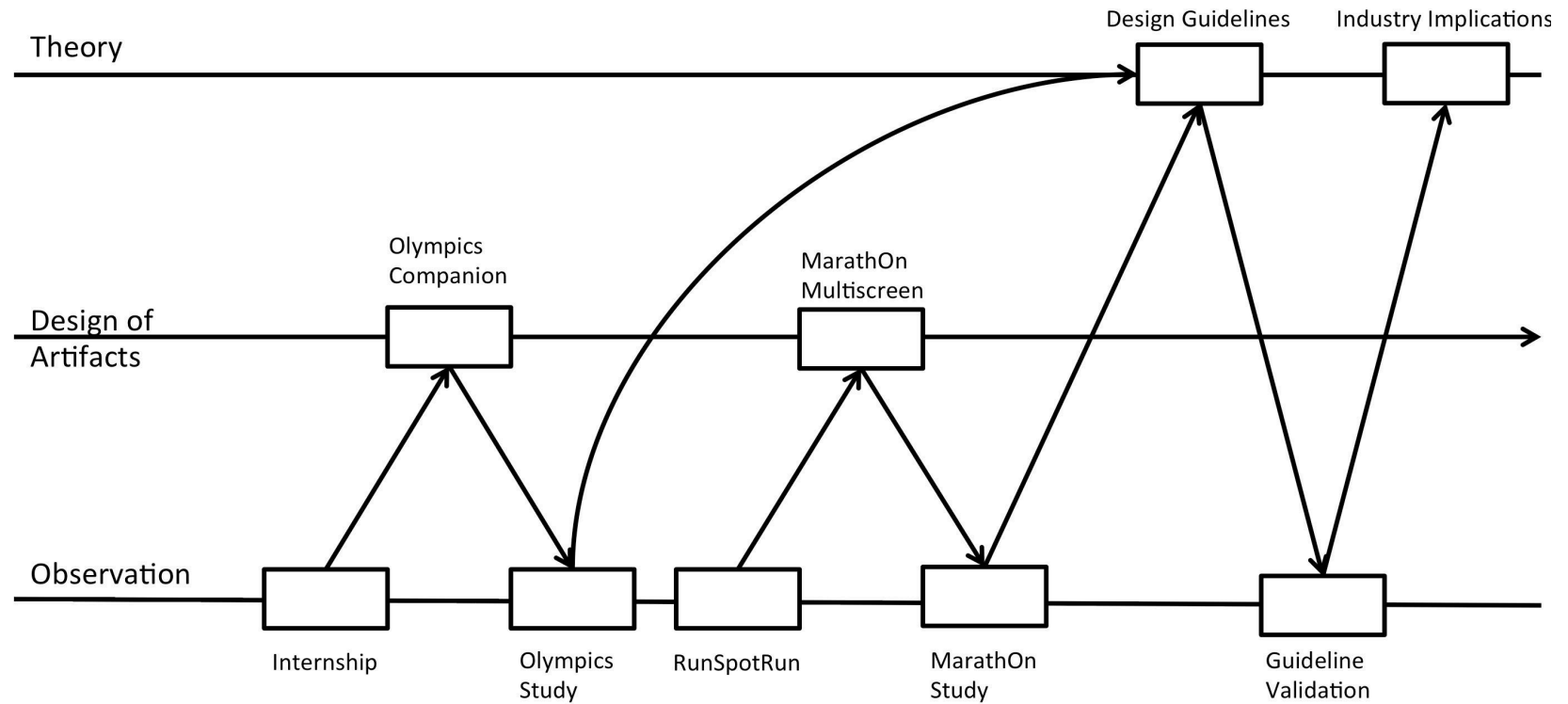


Image 1 - 2 Overview of thesis research process

Image 1-2 outlines the study procedure that was conducted in addressing the thesis questions stated above, the format of the diagram is based on those discussed by Mackay & Fayard (1997), showing the interaction between stages of research activity, including observation to ground prototyping, design of artefacts and the development of theory. In the case of the work conducted in this thesis, theory refers to the development of the design guidelines and the subsequent development of practitioner reflections

The horizontal plane of Image 1-2 represents the duration of the research work conducted in the development of this thesis. The initial activity shows the development of the Olympic Companion Application, grounded in the experiences of the internship at BBC Research and Development and its subsequent evaluation. This is followed by the development of the MarathOn Multiscreen prototype, which is derived from partaking in the RunSpotRun project. The findings of both studies are drawn together in the development of a series of guidelines for design, which are validated through a practitioner group interview leading to further practitioner reflections of the research work. The guidelines and industry validation are discussed in Chapter Seven.

### Lab Observation

The evaluation of the Olympic Companion and MarathOn Multiscreen Applications was conducted in two inductive studies. These studies included observation of the applications in use and semi-structured interviews with participants. The details of the methodologies used in each study are described in chapters Four and Six.

The studies were conducted in a simulated viewing environment that allowed for the manipulation of certain conditions during the study (Kjeldskov et al., 2003), while maintaining the informality of a television watching setting. For example, the introduction of additional tablets during the Olympic Companion study.

The ability to manage the viewing environment is of particular consideration for television watching studies where interaction is traditionally passive in

nature (Nielson, 2008) and take place over extended periods of time. The directable and repeatable approach adopted ensured that within a manageable time frame, a large body of relevant observations could be made by a adequate sample size. It should however be noted that lab based approach introduce some compromises to comprehension and generalisation of the results. An alternative 'in the wild' methodology would more directly consider the applications use in context, contemporary authors warn about the changing nature of results when moving research between the controlled environment of the laboratory and the context of real world use (Rogers, 2011). Therefore, the results and subsequent guidelines should be viewed with the framing that they represent user behaviours within the laboratory setting, framing future prototyping and further evaluation in the wild. The approach used in the design of the two studies reflects other evaluations conducted into interactive television artefacts, where a living room environment is simulated in the laboratory (Pemberton & Griffiths, 2003), adopting comfortable seating and an informal atmosphere.

### Findings Analysis

Participant data from the two studies were recorded using video and through system logs generated by the applications. The use of video data enables a deeper perspective on social interaction and conduct (Heath et al., 2010). Given the focus of the thesis questions on social sharing and organisation, video capture was the suitable choice for observational data capture. Alternative methods, such as audio recording or researcher note taking would have masked the visual details of user interaction and diminished the richness of the data collection. However the depth of data collection is traded against the impact of video observation and its affect on user behaviour. Cameras were mounted during the studies and positioned unobtrusively to minimise this effect. In addition, utilising video data to record user interactions potentially covers a huge range of data, such as non-verbal communication, attention and user proximity. Therefore opportunities for topics of analysis and interpretation by the researcher are almost limitless (Knoblauch & Schnettler 2009).

“It is the focus on the audiovisual aspects of people in action which constitutes the central subject of these video analyses. In more theoretical terms, one could say that the field of video studies is circumscribed by what Erving Goffman called the ‘interaction order’, i.e. the area of action in which people act in visual co- presence – a co-presence which can be captured by the camera. And since what people do covers a huge range of areas, the potential topics of video analysis is almost endless.” (Knoblauch & Schnettler 2009)

The analysis conducted as part of this thesis was guided by the thesis research questions and subsequent objectives set for the two studies, detailed in chapters Four and Six. These objectives provided a “analytic foci” (Sanderson & Fisher, 1994) for the manipulation of the dataset. The results of both studies were analysed thematically. Thematic analysis is a common technique in HCI for extracting meaning from video data when analysing technology prototypes (Brown & Stockman, 2013).

## CONTRIBUTION

The research undertaken to inform the needs of the thesis aim has led to the development and evaluation of two companion television applications designed to reflect the research questions presented above.

The Olympic Companion Application, was informed by an internship conducted at BBC Research and Development at the end of 2012. The application was designed to broadcast a schedule of professional programming from the London Olympic Games. The applications allows users to engage with auxiliary programme content while they watch on either the tablet or the television. The application was designed with a many-screen philosophy, allowing a collocated group of users to interact simultaneously with multiple tablets. An inductive qualitative evaluation of the Olympic Companion Application was conducted utilising 30 participants in 10 groups of 3 users. The investigation highlighted the sharing and scheduling practices of users while watching a multi-sport tournament, in response to the first research question above. During the evaluation users had access to a changing number of tablet devices, allowing users to experience and reflect

upon different configurations of companion device. The Olympic Companion Application has been presented in the following publications:

Anstead, E., Benford, S. and Houghton, R.J. 2013. Conceptualising Dual Screen Applications as Pervasive Experiences in Workshop on Exploring and Enhancing the user experience for television at CHI'13

Anstead, E., Benford, S. and Houghton, R.J. 2014. Many-screen viewing: evaluating an Olympic Companion Application. In Proc TVX '14. ACM USA, 103-110.  
<http://doi.acm.org/10.1145/2602299.2602304>

The second application, MarathOn Multiscreen, was derived from a collaborative project sponsored by the video sharing site YouTube. As a further example of many-screen application MarathOn Multiscreen integrated professionally produced video footage with a large corpus of amateur video footage taken during the Nottingham Robin Hood Marathon in 2013. The application incorporates lean-forward interactions, allowing users to sort, organise and select footage from the amateur corpus, in addition to lean-backward viewing. Contrasting with the Olympic Companion Application where interaction was predominantly lean-backward. Similarly, the application was evaluated in a qualitative study that involved 30 participants in interacting groups of three participants for each study instance. The investigation sought user opinion on the value of the amateur video in relation to the professional content and user investment in the video footage. In addition, the evaluation generated observations of user configurations while engaging in the lean-forward tasks afforded by the application's interactions with the amateur video footage.

The MarathOn Multiscreen Application and evaluation is published at:

Anstead, E., Benford, S. and Houghton, R.J. 2016. MarathOn Multiscreen: Group Television Watching and Interaction in a Viewing Ecology. In Proc CSCW '16. ACM USA, 103-110.  
<http://dx.doi.org/10.1145/2818048.2820003>



In addition, the prior project, RunSpotRun, which generated the corpus of amateur video used and inspired the application's focus and direction is published in Flintham et al., (2015).

As stated in the thesis aim presented above, the core output of the conducted research is the development of a series of design guidelines, which inform the design and development of future many-screen television applications. These guidelines were subject to an industry validation exercise that was conducted with members of BBC Research and Development towards the end of 2014. The aim of this exercise was to ascertain the relevance of the guidelines and opportunities for implementation within the broadcast industry.

### Research Contribution

In addition to the design focused guidelines this thesis contributes to the body of HCI literature on second screen television, mobile television and groupware systems.

This thesis builds on existing second screen literature by looking at experiences that take place across multiple companion devices and experienced by a collocated group of participants. Ethnographic work conducted in the home and some current second screen literature points to the socially situatedness of television watching. While some studies have focused on the use of social media to converse about a programme (Doughty et al., 2012) few have looked at groups of users interacting together with a companion experience. The two studies presented by this thesis represent initial probes into these kinds of systems, as such the discussion that concludes this thesis and the study limitations sections point to opportunities for further research to develop this area of study.

The MarathOn Multiscreen study uncovers issues on the confluence of user generated content and multiscreen television that aids understanding of collocated collaborative interaction and highlight implications for existing groupware research. Currently experiences are of multiscreen television watching is ad-hoc, and the collaborative context is poorly understood.

CSCW techniques and practices surrounding groupware in other collaborative contexts may offer the opportunity to extend a richer understanding. However, a key tension remains; television watching is embedded in the domestic context and is often about entertaining and relaxing experiences rather than productivity and performance (Chorianopoulos & Spinellis, 2006). Therefore, transferring known practice and techniques from other contexts, any incorporation will also need to be sensitive to the specific nuances of television watching.

## THESIS OUTLINE

This introductory chapter has presented an overview of second screen television and outlined the motivations and questions posed through the development of this thesis' contribution. In addition, the methods and processes used throughout have been discussed and justified. The following list outlines the contents of each subsequent chapter:

**Chapter Two:** This chapter further introduces the grounding literature that precedes the development of this thesis. The review discusses the literature around second screen applications and their wider deployment through industry developments. The review goes on to discuss literature from other HCI paradigms which maybe useful in informing the design and analysis of multiscreen television. The chapter concludes with an overview of literature on user-generated content, focusing on video and its integration in television viewing practices.

**Chapter Three:** Discusses the internship that formed the design of the first study at BBC Research and Development. The chapter begins by introducing the relevance of the BBC as an industry partner for shaping work on second and multiscreen television, including prior efforts deployed by the corporation and investigated by the research group. This is followed by a description of the primary output of the internship, the development of the Olympic Companion Application. The iterative development process is discussed and the applications functionality explicated and justified.

**Chapter Four:** The evaluation of the Olympic Companion Application, including study design, methodology and results. The evaluation centres on the methods of sharing and scheduling the Olympic content by a collocated group using the application, across an ecology of devices that changes in size. The chapter concludes with an initial discussion of the study findings.

**Chapter Five:** The RunSpotRun project that inspired the development of the second thesis study, MarathOn Multiscreen, is outlined. Further to this the rationale behind the MarathOn Multiscreen Application and its design are discussed. In addition, the chapter outlines the technical underpinnings of the application, describing the multiscreen software platform that was constructed to aid in the development of applications similar to the two discussed in this thesis.

**Chapter Six:** This chapter details the process and results of the MarathOn Multiscreen Application evaluation. The evaluation investigated the interplay of professional and user-generated content and the organisation of users when searching and sorting through the corpus of data generated during the RunSpotRun evaluation. This chapter's structure mirrors the structure of Chapter Four, including the study design and methodology, findings and initial discussions.

**Chapter Seven:** Presents a broader discussion of the study findings presented as a series of guidelines for designers developing many-screen television applications, such as those discussed by this thesis. The guidelines are followed by the design and findings of a validation exercise conducted with researchers working at BBC Research and Development. The exercise was designed to add practical understanding of the implementation of the guidelines and their relevance to the industry context.

**Chapter Eight:** Concludes the thesis by returning to the thesis questions set out in this introduction and summarises the findings and discussions from earlier chapters. In addition, this concluding chapter will highlight the

limitations inherent in the work presented in this thesis and elicit possible avenues for future research with multiscreen and many-screen television.



# CHAPTER TWO

## *Review of Existing Literature*

This chapter comprises a review of existing knowledge in the paradigm of companion applications, HCI notions of multiple screen and mobile television, the role of technology in the home and an overview of research on user-generated video. The purpose of this literature review is to establish the theoretical underpinning of extant work on multiscreen television and to establish research gaps in current knowledge.

The review begins with a broad definition of interactive television before exploring in detail current work on companion television applications, from both academia and industry. Subsequently research work from other human computer disciplines will be explored to identify avenues for further informing the design and analysis of many-screen television. These descriptions will come from a range of approaches including, single and multi display groupware, the use of ecology as a descriptor of social technical ecosystems, mobile television and investigations into the home as a context for HCI research. The final area of literature considered investigates user-generated content, paying particular attention to the use of crowd-sourced video in the context of sports events.

The chapter concludes with a summary of the research surveyed and how it adds further grounding to the research statement presented in Chapter One.

## INTERACTIVE TELEVISION

The principle of television audiences interacting with television programming is not a new concept and predates the advent of digital broadcasting. Analogue examples of interactive television (iTV) can be dated back to the middle of the twentieth century and the popularisation of television itself. 'Windy Dink and You' is often credited as the first example of interactive television (Smith et al., 2004). The programme, which was first broadcast in the United States of America in 1953, gave an illusion of interactivity by allowing children to draw on a special acetate sheet that adhered to the television using static electricity. Viewers could therefore interact with the programmes narrative, during the programme they would be prompted to colour in graphics on the screen or to complete 'join-the-dots' puzzles to reveal new characters or objects that join the story. Other, more recent, examples of interactive television applications that have come to prominence include Teletext services such as 'Ceefax', and the 'red button' interactive channels that replaced it. Nevertheless, many forms of interactive service have struggled to capture viewer appreciation and those included with digital television services have received indifferent opinion from users (Theodoropoulou, 2002).

Interactive television has been of interest to range of researchers from HCI and related sub-disciplines, and media and communication studies (Cesar & Chorianopoulos, 2009). Jensen (2005) categorises the major areas of investigation for interactive television:

**Electronic Programme Guides (EPGs):** On-screen channel guides that show viewers the forthcoming programming. EPGs have received considerable investigation in HCI and are discussed in detail in the second screen television section of this chapter.

**Enhanced TV:** Interactive overlay on programming that allows users to engage with additional content, this could include play-along quiz shows or additional sports feeds.

**Video-on-demand:** Allows users to breakaway from the traditional model of broadcast television and to watch programming when they want. Jensen describes both true on demand services and 'near-video-on-demand' services which broadcast the same programme on different channels with sequential time slots.

**Personalised television:** Jensen defines personalised TV as a broad category of interactions where users are changing the presentation of programming to suit their own viewing and interests. This includes the use of pause, rewind and fast-forward functionality using a personal video recorder (PVR) and extends to selecting alternate views and angles, allowing the viewer to become their own editor. A complex example of personalised television from the literature is interactive documentaries, which allows viewers to select from a branching narrative to best determine their learning path while maintaining a coherent narrative and aesthetic throughout the programme (Ursu et al., 2009).

**Internet@TV:** The transfer of web based content from the PC to the television. Jensen propose two methods by which this could be achieved either by transmitting a small number of websites to the television using the broadcast system or by downloading through the household Internet connection when pages are requested. In addition, Internet@TV services could enable other services such as chat and messaging, including services allowing viewers to communicate directly with the programme makers during the show.

**iTV Advertising:** interactive television services could be used to target and distribute personalised advertising.

**T-Commerce and Home banking:** Allow users to conduct their banking and shopping through the television. This could be conducted alongside television shopping channels.



**Games and Betting:** Play-along services either driven through television broadcast or downloaded as stand alone experiences. These experiences may be free to play or require cash transactions.

Jensen's descriptions of the types of interactive television are comprehensive and in some areas the author has predicted the current zeitgeist in the adoption of PVRs, EPGs and a preference amongst some users to use video-on-demand services, such as 'Netflix' for their viewing. From other angles however it appears quite antiquated 10 years after its publication and this trend was indeed predicted by the author. The notions of 'T-commerce' and 'Internet@TV' it would appear have not come to fruition in the method intended. Instead of these actions being part of the television experience, they mediate them. Allowing users to bring other devices and services to their television viewing practices.

In addition, Jensen's treatment of interactive television does not include opportunities for viewers to become part of the television programming and explore a communication backchannel between viewer and producer. In the discussion of socially grounded second screen applications in the next section examples of this kind of system will be explored. While the article touches on chat between viewers and broadcasters, there has been a stronger than predicted uptake in user-generated content, including citizen journalism.

Attention will now turn to second screen television as a subset of interactive television experiences and the focus of this thesis.

## SECOND SCREEN TELEVISION

The simultaneous transition of television sets into Internet connected media devices and the ubiquitous rise of smartphones and other small form factor consumer computing devices have facilitated synchronised interaction between mobile smart computing device and the television (Basapur et al., 2011). Second screen, dual screen or companion television viewing builds on the notions of interactive television but takes interaction away from the

communal screen and places it on an auxiliary device. Early examples of interaction between the television and a mobile computing device from HCI literature include Robertson et al.'s prototype of a real estate information service (1996). The application used a PDA (personal digital assistant) for selection, searching and relaying textual information about properties for sale to the user. The high quality image display of the television was synchronised with interactions on the PDA and used to show pictures and video of the selected houses for sale. Communication between the television and the PDA was carried out by infrared signals as the system predated the inclusion of wireless networking in smart devices. Part of the novelty of this work stemmed from the use of the PDA application as more than a limited control device, allowing users of multiple devices to interact and control the PDA and the television. Robertson et al. Made use of the television as a display for showing users media artefacts related to houses for sale, this study is marked out from others of the period, including those described in the Multiscreen In Computer Supported Cooperative Work section below, as it focuses on the domestic context of the home and interaction with the consumer orientated television. Other studies contemporary to Robertson et al. made shared office devices, such as digital whiteboards and projection screens, the focus of interaction. However, Robertson et al.'s work did not interact with the broadcast programming that is traditionally delivered to the television.

### Second Screen Television

In a preliminary description of companion application paradigm, Cesar et al. (2008) describe the prospects for companion experiences that interact not only with the television but also with the content delivered by broadcasters. Within the authors propose four basic usage scenarios for second screen television that enable users to “control, enrich, share and transfer television content” that are distilled into three basic end user behaviours for development into a second screen architecture:

**“Personal content selection/preview”:** Navigation, searching and scheduling of television content using the second screen, this could include

recommendation of content based on ratings or recommendations from other users.

**“Presentation continuity”:** Seamlessly pick up and resume content viewing on other devices. For example, when having to stop watching a programme on the living room television being able to resume later on a tablet in the bedroom.

**“Micro-personal recommendation generation and sharing”:** messages recommending programmes to others within the family or others within a user’s social network. These messages could include short clips of programme content with user-generated visual overlays, augmentation, or voice commentary.

In a later work the authors describe in more details the architecture that underlined the prototype system described above, which allowed for multiple devices, both televisions and smart devices, to be connected simultaneously to a content delivery system (Cesar et al., 2009). This system also employed the use of the SMIL presentation mark-up (Synchronized Multimedia Integration Language) (Hoschka, 1998), which allowed for content to be divided into short clips and augmented by users. The three user behaviours exhibit some of the functionality that has been reported in other HCI literature on second screen television, following work has however exhibited a broader range of experiences. The four usage scenarios of control, enrich, share and transfer content, however provide a useful framing for both earlier and subsequent work in the field. The following subsections detail prior work on companion applications and are organised utilising the usage scenarios described by Cesar et al. (2008).

### ***Control***

Several studies on second screen deployments have reported on the separation of television interaction from the traditional method of remote control linked to on-screen graphics using an electronic programme guide. EPGs are traditionally presented as a horizontal grid of channels showing the

upcoming schedule. Cruickshank et al., (2007) were among the first to propose the benefits of moving electronic programme guide content onto an auxiliary device. They propose that overlaying the EPG onto the television screen is problematic as it hides the main current programme content, which may lead to issues with co-viewing in shared space of the living room. In addition the authors suggest that pushing the programme guide to a secondary display enables deeper personalisation and recommendation. The design of the system was grounded in user interviews in the home and after development was evaluated in the domestic setting. Users responded positively to the prototype and highlighted the advantages of taking programme guide content away from the main display.

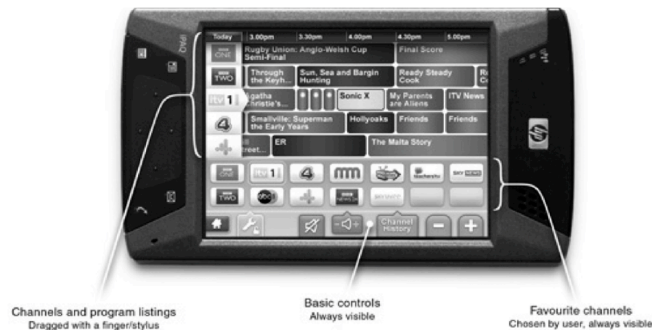


Image 2 - 1 Second screen EPG (Cruickshank et al., 2007)

In an earlier study Park et al., (2006) conducted a participatory concept designs exercise with potential users and an ethnographic study to establish potential functionality for EPG applications. They uncovered a number of use cases that were enabled by utilising a second screen application that would not be implementable on the television screen. For example, personalised organisation, recommendation and integration of social networking for individual users, and enabling family voting on what to watch next. Park et al. and Cruickshank et al.'s propose functionality to alleviate the potential for domestic tension when using the EPG on a shared display. Both articles show a balance between allowing the individual user agency to make personalised choices, while embedded within the social context of the living room and watching television.

The EPG, as a primary means of interacting with digital multichannel television, has received attention from other quarters of the HCI community although not necessarily concerned with its distribution to an auxiliary display. Examples of this work have centred on accessibility, considering users with visual impairments (Turunen et al., 2010 and Oliveira et al., 2011) and through speech interfaces for those with restricted mobility (Johnston & Stent, 2010 and Soronen et al., 2009). Other prior examples break away from the traditional channel grid approach to programme layout and instead offer users a more intuitive layout of genre, mood or connections with other liked programmes (Harrison et al., 2008 and Abreu et al., 2014)

The Newstream prototype is further second screen example of a control device for the television that integrates programme selection functionality with social networking recommendations (Martin & Holtzman 2010). The prototype integrates news media with the user's social network to deliver personalised news content independently from source producer and device. This example is contrasted from the work presented earlier in this section in that it is designed to enhance the television experience through distributed social networks, instead of enhancing the collocated social experience of watching television at home. In addition, it is also distinct from other authors who embed the social experience into the EPG, such as Iatrino & Modeo (2007).

### **Share**

Most of the existing literature directed at the sharing of programme content using second screen devices considers the use of ad-hoc media meshing (Office of Communication, 2013a) between geographically distributed users interacting with social networking services. Lochrie & Coulton (2012) and Doughty et al. (2012) investigate the reach of social networking in enhancing the shared experience of television viewing. Both papers discuss the impact of social networking tweets on the popular 'X-Factor' talent show, with comparisons to political debate programme "Question Time" made by Doughty et al. Lochrie & Coulton highlight the inter-audience interactions that were enabled by the services while viewers were watching the

contestants. They note, that while the method of second screening is away from the broadcasters control or provision it enables a backchannel for broadcasters to enhance their programming with additional user-generated content, relaying popular or interesting tweets to viewers as the show progresses. A different approach is adopted Doughty et al. who apply a formal social network analysis to extracted tweets from the contrasting genres of programming. Their analysis showed that the impact of tweets on the community of users, measured by mentions and retweets, was enhanced by the originators status, such as whether they are a celebrity, someone involved in the programme or the twitter account of an organisation.

Basapur et al. enhanced television programming with an augmented content stream, which had been generated from social media updates, the prototype they built was called “FanFeeds” (2012). The social statuses in this prototype contrast the above in that they were bespoke to the platform and not harvested from services such as Twitter. This work builds on earlier research from the same research lab that developed a second screen application that enhanced programming with auxiliary synchronised information updates from third party sources such as Wikipedia and news outlets (Basapur et al., 2011). The later study enabled sociality between users watching programming in different locations and at divergent timing. The prototype application discussed, by Basapur et al. (2012) was designed to be operated in time with television media, however that did not avoid the possibility of programme spoilers generated by other users’ social updates. The revealing of spoilers was seen by some users in the applications evaluation as being detrimental to the television watching experience, pre-empting sports results or revealing a programmes poor quality before watching.

### *Enrich*

Both the above examples from Basapur et al. (2011 and 2012) highlight the use of a companion to enrich the experience of television watching with a second screen device. The FanFeeds system did this by introducing a social network, timed to synchronise with the watching of television programmes, while the earlier dual screen experience introduced content from third party

sources to augment the viewing experience. Other work has provided enriching additional content to be paired alongside the television broadcast offers learning opportunities (Fallahkhair, 2005) as well as adding to comprehension of the programmes narrative. In two articles from the 'eTV Laboratory' at Georgia Institute of Technology, the abilities of companion applications to support long arc television narratives, that take place over many episodes and series, are explored (Murray et al., 2012 and Nandakumar & Murray 2014). In the 2012 article Murray et al. Discuss the opportunities offered by second screen applications in allowing new viewership to catch-up with a series midway through or to support the comprehension of the casual viewer. The long running programmes 'Lost' and 'Game of Thrones' are cited as examples of programmes with complex narratives and character relationships that could benefit from enriching content delivered on a second screen display. The companion described in Murray et al. Centres on the cowboy western 'Justified', displaying character biographies in time with their appearance on the television screen, allowing viewers to recap major themes in the narrative and discover inter character relationships. The later article, authored by Nandakumar & Murray, discusses an in-depth evaluation of the companion application.

The prototype evaluation uses a between samples methodology, where some users were asked to watch a mid-season episode of 'Justified' with the companion application and others without, none of the participants had seen any episodes of the programme before. Those that watched with the companion were observed to have an increased comprehension of the programmes content. In addition, to the importance of maintaining synchronisation between television and tablet, findings highlight, the different experiences of viewing that collocated users might have and that functionality such as automatic pausing of content based on user interactions with the companion may impact others viewing.

### ***Transfer content***

The transfer of content between the primary screen of the television and a secondary display has thus far received less attention in the academic

literature on companion devices and applications. This directly contrasts with industry developments where screen mirroring has been implemented by devices and protocols such as Apple 'AirPlay' (Apple, 2015) and Google 'Chromecast' (Google, 2015). However the challenges of content transfer in collocated environments, with devices such as these have been investigated. McGill et al. focus on the challenges of self management of multiscreen content transfer by small groups of interacting participants (2014). They uncovered through a series of experimental conditions that the ability to collaborate is greatly enhanced by the inclusion of interactions that allow for users to pass, take or relinquish control of the shared television display.

### Second Screens In The Television Industry

Companions and other second screen experiences is a growing field of interest, not only to academics working with interactive television but also to the broadcast industry. Applications designed by the BBC, the location of the internship that defined the design of the Olympic Companion Application, are discussed in detail in Chapter Three. Their current efforts involve the development of several publicly deployed applications and research centred prototypes of programme specific second screen applications. In addition, BBC Research and Development department have designed a platform to support the construction of multiscreen applications that interact with broadcast transmission.

The developments conducted by the BBC are symptomatic of a wider industry interest in the area. The majority of these publicly deployed applications offer enriching experiences to users and the opportunity to share their abilities, opinions and preferences through social media platforms. While the exploration of companion applications has been applied to a number of programming genres, a significant proportion of the publicly deployed applications allow viewers at home to play along with quiz formats. Quizzes such as 'Who Wants To Be A Millionaire' (ITV, 2013) and 'The Million Pound Drop' (Channel 4, 2014) allow viewers to play along at home in synchronisation with the broadcast. The latter of these examples allows players to connect with friends on social media to compare scores and apply



to become an on-screen player. In addition, the 'Million Pound Drop' application is used as a backchannel of communication between audience and the broadcaster, whereby the on-screen presenter talks about the performance of players at home, highlighting the relative success of different demographic groups or in later stages of the game winning individual players. Dutch game show 'Intuïtie' extends the idea of a programme specific companion by making the second screen experience core to the programmes format. The daytime quiz show does away with studio contestants and the only players are those playing at home with the companion mobile app or website (Intuïtie: A Revolutionary Two-Screen TV Format, 2011).



Image 2 - 2 'The Million Pound Drop' second screen application (channel 4, 2014)

Another popular television format for augmentation with a second screen is that of the reality talent show, such as 'XFactor' (The Guardian, 2011) and 'The Voice UK' (Discussed in more detail in Chapter Three). These applications offer a moderated view of social networking updates that pertain to the programme and allow viewers to rate and compare opinions of different acts.

Although the majority of publicly deployed examples centre around reality and non-dramatic programme formats enriching features have also been developed for serial narrative television. For example, 'The Walking Dead Kill Counter', allows a viewer to guess the method of execution and the number of zombies killed during an episode. 'Disney Second Screen' that

gives children additional content for classic films such as 'The Lion King and Lady And The Tramp' offers a more gentle companion experience. In both these examples the second screen application is synchronised to the main content through analysis of the audio track of the programme or film. This ensures that the companion application is played at the same time as a viewer is watching, regardless of whether they are watching on DVD, live television or through a catch-up service.



Image 2 - 3 The 'Walking Dead' kill counter application

### *Sports Applications*

The focus of the two applications developed for this thesis is the genre of sports television programming. Sports programming often includes in-depth statistics, additional camera angles and replays, and expert opinions to enhance the viewer's experience and comprehension of events. The structure of sports programming lends itself to the second screen form allowing for deeper content beyond what is available in the linear narrative broadcast and offering users agency in selecting perspectives on the unfolding match or competition.

Several applications centring on sports programming have been developed and deployed by broadcasters. The Formula one application allowed viewers to choose alternative views of a F1 race, choosing to follow particular drivers or part of the course, as well as deeper statistics about what they were watching on the main television feed and a moderated social networking feed (SkySports, 2013). A more general approach to the delivery of sports highlights is enabled by the ESPN Xbox SmartGlass application. The application transfers the interface for selecting and engaging with highlights and statistics from the television to the companion device, reducing on screen “clutter” (Patel, 2012).

The following subsection summarises the work discussed above and offers an interim discussion introducing how this existing research into second screen television can be further informed by work conducted into other fields of HCI, which the next section of this review is comprised of.

#### Dual Screen Television Discussion

The above literature shows a small but growing area of interest for human computer interaction researchers in investigating second screen and companion applications for television augmentation. The majority of these studies have researched the enrichment of television programming with additional content presented on a second screen, and the sharing of opinion and information with other viewers using social networking platforms. Less of the prior work has investigated the possibilities of content transfer between companion and television or the utilisation of the second screen as a control device beyond the EPG.

The existing literature in this section shows investigations into sharing the television watching experience. Much of this work focuses on the utilisation of social media as an ad-hoc approach to companion viewing. As users’ communication about what they are viewing is increasingly mediated by these platforms this is an important route for investigations to explore. The social collocated experience of viewing has received less attention, some authors have reflected on the advantages and challenges of multiscreen

television applications in avoiding the social issues of overlaying the EPG on the television (Cruickshank et al., 2007) or organising screen mirroring (McGill et al., 2014), and others have touched upon the companions ability to enrich the living room experience (Basapur et al., 2011). However, studies that focus on the sharing of television content across multiple displays while watching together is less evident from the literature. This adds impetus to the first of the thesis research questions discussed in the previous chapter, investigating the social sharing of television content across multiple display devices.

The trend of investigation into companion viewing has been replicated by industry efforts and this validation suggests a field where work from the research community can impact and benefit consumers. HCI's interest in interaction that takes place across numerous devices is not a new development in the discipline, in fact multiscreen prototypes and examples existing in the literature date back to the earliest developments in computer supported cooperative work. The following section outlines developments from other HCI paradigms that inform and are challenged by the development of multiscreen television. Multiscreen groupware from CSCW, display ecologies and mobile television are discussed below.

The first three of these paradigms inform interactions that take place between multiple users across multiple display devices, and maybe useful in informing the design of multiscreen television applications that are informed by a collocated environment. However, much of the prior work in these areas discusses investigations carried out in the work place or public settings outside of the home. Television watching, while social is also a relaxing and entertaining pursuit that takes place in a particular context, metrics such as efficiency and performance are not the primary consideration, instead systems maybe evaluated by user engagement, lack of frustration or entertainment value. Existing HCI practices and approaches may need to be reconfigured to work effectively with interactive television applications and systems. Since iTV and multiscreen television serves diverse population, who

are engaged in entertainment and leisure pursuits (Chorianopoulos & Spinellis, 2006).

## MULTISCREEN HCI

### Multiscreen In Computer Supported Cooperative Work

CSCW is a sub-discipline of HCI concerned with the investigation of how people work together using both physical and digital artefacts and practices (Grudin, 1994). Traditionally CSCW research has focused on users in the work environments, however more recent literature extends the reach of the discipline to other environments including the home (Grinter et al., 2005).

Groupware has been a key tenant of CSCW work since its appearance in the mid 1980s; innovations span multi and single display architecture, and collocated and distributed environments. One of the earliest investigations is the Colab meeting room, which proposes an interconnected network of multiuser interfaces providing users with a simultaneous shared access to meeting resources (Stefik, et al., 1987). This investigation formed the basis of the WYSIWIS (what you see is what I see) abstraction. A WYSIWIS multi user environment attempts to encapsulate the physical properties of a blackboard, while making use of the computational benefits of persistent storage ,and the interactive ability to reorganise and redisplay information. In the associated analysis of a WYSIWIS meeting system Stefik et al. assert that the group dynamics within the meeting room environment are consistently changing and updating, subgroups are being established and abandoned. User attention and awareness shifts between different display devices, encouraging the design of a lightweight unrestrictive system, which does not force all users in the meeting environment to maintain the same focus throughout the interaction.

Coen et al. present a middleware solution to the development of intelligent environments that support human processes on “their own terms” (1997). Called Metaglué, the system was deployed in a hypothetical future collaborative room that represented the requirements of a meeting room or military command station. Metaglué promotes a lightweight modular system,

which minimised the required support infrastructure but allowed for the continually changing configurations present in intelligent environments. In addition, the system was required to affectively handle multiple simultaneous user interrupts and events.

The WeSpace system is a more contemporary example of a multi-device, multi-user collaborative work environment (Wigdor et al., 2009). Initial analysis of WeSpace has focused on the benefits of deployment in pure scientific research. The environment enabled by the system allowed for the integration of personal laptop computers, an interactive table surface and a projection screen. Users were able to share their laptop screen with the rest of the assembled group using the projection screen, while the table top provided a collaborative interactive space. The evaluation showed within the context of scientific research the system allowed for collaborative process to happen earlier in the process. As well as allowing for more effective collaboration, where a scientist individual data could be displayed next to one another for immediate and efficient comparison.

### *Single Display Groupware and User Feedback*

The CSCW interest in co-present groupware spans beyond interaction across many devices to those that inhabit a single display only. Single Display Groupware (SDG), allows multiple collocated users to interact with a single shared computer with multiple input devices (Stewart et al., 1999). Stewart et al.'s study of a children's drawing application, contrasted shared interaction using a single display with a single interaction mechanism against multiple points of interaction. User opinions that formed the studies findings found the later condition to be both easier to use and more enjoyed by the participants. Examples of single display groupware appear in the literature prior to Stewart et al.'s definition of the form, for example the MMM project (Bier & Freeman, 1991). MMM stands for "Multi-device Multi-user Multi-editor" and provided an interface and architecture that facilitated document editing by multiple users, using multiple pointing devices but a single display. Key to the systems success was the use of "per-user feedback", which directed users to their own interactions, notifications and highlighted their sphere influence on the wider

screen display, this was achieved through colour coordination of on-screen elements. Through early evaluation with the system Bier & Freeman conclude that the colour coding allows for the use of familiar interactive feedback metaphors and the use of “home areas” on the display was a successful way to assign a pointing device to a user. Equivalent ideas to per-user feedback are also considered by Gutwin & Greenberg (2000), who investigated enhanced workspace awareness support in distributed groupware. The enhancements were observed to improve users’ performance in certain tasks such as informing another participant how to focus specific locations or objects in the shared workspace.

Shoemaker and Inkpen (2001) highlight the issues of single display groupware in protecting individual users’ privacy, where a user’s personal information is potentially made available to all users on the shared display. Their solution involves the use of a stereoscopic display and 3D glasses to display different images to two users or groups of users. This enabled users to work independently of each other and to switch back and forth between individual and collaborative exercises. Other work on single display groupware has investigated the communication issues of interacting users while wearing headphones (Ringel-Morris et al., 2004), uncovering an increase in productivity and frequency of discussion between participants.

### Display Ecologies

Nardi & O’day (1999) introduced the ecological metaphor as a descriptor of the interplay between digital technologies and the social structures they share with their users. In their work on information ecologies, they reason that the richness of the ecology metaphor is necessary to capture the diverse complexity of the spaces that are inhabited by technological installations. Computer deployments mediated not by the discreteness of digital infrastructure, or task efficiency but by the endless variety of social practices, economies, politics as well as the motivations of the activities at hand. Nardi and O’Day consider information ecologies to be significant in allowing users to take on a pivotal role in shaping how technology is used and adopted. Their descriptions of information ecologies rallies against the determinist

view of technological change as an inevitable force but one in which the wider population can be informed and able to make decisions on best practices given their unique setting. Other HCI researchers have used an ecology metaphor to describe the experience of visiting cultural sites and museums (Bell, 2002), and an ethnomethodological perspective of configuring interactions between users of mobile or ubiquitous computing technologies and users interacting with virtual worlds (Crabtree & Rodden, 2008).

The phrase display ecology was first used to describe the mission control infrastructure for the Mars Exploration Rover mission (Huang, 2006 & Huang et al., 2006). The collaborative environment of the mission control system made use of a network of foot and yard scale display technologies. Despite the component devices not having been designed with their interconnected use in mind, their deployment in this mission critical, frantic environment required each to play an affective role in the interactive loop. Key to Huang et al's evaluative findings is the dynamic, undefined and changing nature of interaction in collaborative environments. The nature of collaboration and types of tasks performed across situated display systems was seen to evolve over time as knowledge and practices were shared between group members as the mission unfolded. These factors shaped significant interactive challenges faced by the display infrastructure at different stages of the mission.

Terrenghi et al. (2009) describes a taxonomy for display ecosystems focusing on the interactive implications of their use in collaborative environments. The taxonomy establishes three main factors affecting the geometries of interaction. The first factor considers the size of the ecosystem, how many devices, users and the physical proportions of the space of deployment relevant to the attributes of the display devices. Secondly the nature of the interaction that the ecology enables, for example is the network deployed in a social, domestic or work setting. The final factor examines the interactive metaphor which enables the coupling of the displays to the ecosystem and



the transfer of interactive and interface elements. The need for a taxonomy is rationalised by Terrenghi et al. for the designers of coupled display systems to approach the complex issues of interaction from an informed standpoint and to separate these considerations from those of an infrastructure that supports it.

## HCI IN THE HOME

Much of the work discussed in the prior section has focused on the deployment and appropriation of technologies in the workplace and public spaces. As the fields have developed, the focus of HCI and CSCW has expanded to include other aspects of life that are increasingly mediated by computation. The home is one such location and is relevant to this thesis as it forms the primary location for television watching. Domestic spaces are of particular challenge to HCI researchers as they involve complex practices and distinct social structures. The metrics of efficiency and performance are not of the same interest for technologies that are evaluated in the home; instead focus is on “fun, pleasure, emotion, effect and aesthetics” (Bell et al., 2003).

Work that is conducted in the home applies to a broader set of users than research that is conducted in the workplace. Elders, children, babies and pets are equal actors to those of working age. Additionally, the relationships between members of the household do not involve the strict hierarchy of workers in places of business (Hindus 1999). However, work involving children, other vulnerable groups and taking place in the private space of the home have to carefully consider the ethical impact of their work and the need for such invasive methodologies.

Historically authors have asserted that the home differs from traditional locations of HCI research not only in the user demographics and the appropriation of new technologies but also by the distribution of the infrastructure that supports their deployment (Hindus 1999). Today, our homes are now digitally enabled spaces with the deployment of home Wi-Fi networks, broadband and mobile computing commonplace. This assertion

should be viewed with the caveat that technology is not universal in all homes and users often do not have a deep understanding of how best to make use of the infrastructure.

Work into understanding the home has predominantly been through ethnographic studies of people's life in the home or through the development of living laboratories, where studies can be conducted in a controlled environment.

Kidd et al., (2009) provide an example of a living laboratory that was being constructed at the time of their work. The 'Aware Home' was a purpose built lab for research into everyday lives and challenges to interaction. This included the potential for investigations into the interaction of personal and wearable devices. The house's infrastructure is capable of identifying occupants' movement around the property and methods by which the house's sensor network can help users find lost objects. The principles of a smart home, purpose built for the evaluation of new technologies, has not been utilised by all authors for the development of new technologies for a domestic environment.

Those that take an ethnographic approach to understanding the use and deployment of digital technology in the home include Crabtree and Rodden (2004). The authors see the need for new analytic tools that inform the design of technologies that understand the practicalities of domestic life. They use domestic routines as a lens by which to analyse home life. Their study shows the communication between family members mediated through an "ecological network of displays". A more recent, mixed methods, approach to social research in the home is demonstrated by Mitchell et al. (2014). Here the researchers employed additional techniques to aide in their understanding of how families use energy and mechanisms by which their usage could be reduced. They appropriated the use of interactive floor plans to discuss movement through the house and finding family routines, and they recorded video tours through homes with the participants discussing their actions and practices.

### Television Watching

Attention now returns to television watching, however focus centres on the embedding of television watching in the home setting and reflects on work from other HCI perspectives, which may further inform the design and development of companion applications.

As an important part of the ecology of home technologies and domestic routines the television has been the subject of several studies into home life. Barkhuus and Brown (2009) note the significant refinement of television over the last three decades with development of video cassette recorders, DVD players and personal video recorders, and more recently downloading and streaming video content from the Internet. In their study on home entertainment usage, which primarily consisted of user interviews, they outline how modern television watching is enhanced by these technologies giving users greater agency in what they watch. They describe how current digital media allow users to construct their own schedule of programming through content access enabled by torrents and PVR recordings. This allows viewers to be more proactive in their viewing habits. They state a trend of viewers increasingly engaging with television as 'lean-forward' users. This contrasts with the traditional view of television as being a 'lean-back' activity, where users passively interact with content (Nielson 2008). Taylor & Harper (2003) further mark the distinction in the structure of viewing based on the time of evening that the television is being watched. They note that viewers in the early evening are more likely to be disengaged with their viewing choices, using the television as a means of "switching off" at the end of the day, later in the evening viewers are more discerning and considered, especially when household chores have been completed and the television is not shared with children.

### Mobile Television

A further field of HCI research that may help to inform the design of multiscreen television and companion applications is that of mobile television. With television distributed to a mobile phone a personalised and individual experience of watching contrasts with traditional modes of

communal viewing. HCI research has for some time been concerned with the experience and presentation of television programming on a mobile device. Early concerns around the delivery of content and presentation on a low resolution screen, such as those presented by Knoche et al. (2005), have been reduced by contemporary portable computing devices. Knoche et al. conducted a study investigating the effects of low resolution encoding on the experience of television content, however modern smartphone resolution is near equivalent to HD TV and high speed mobile networks and public wireless Internet can be used to efficiently deliver high quality video to devices.

Buchinger et al. (2009) provide a useful distillation of studies into the use of mobile TV from different cultures. The authors note a marked difference in studies from Germany, Austria and Japan, which show users to engage in short form content publicly. In a similar and earlier study conducted in Finland, Södergård (2003) reports on usage patterns of mobile video watching and observes similar short viewing periods and users often focusing on just the audio stream and not watching the associated pictures. This is contrasted with users in the United Kingdom, Belgium and South Korea who use mobile television privately in their own home, protecting the user's privacy and to avoid disturbing others in public, therefore viewing occurrences were longer and users observed to be more engaged. Buchinger et al. also highlight the challenges of watching television on a mobile device while using headphones, this finding is mirrored by Miyauchi et al. (2008). Authors of both articles observed a reluctance to wear headphones, not associating them with normal television practice and not wanting to feel isolated from their surroundings. This was not however a universal finding, with some users adopting headphones to watch television on a mobile device, Buchinger et al. posit that this maybe a specific issues to users from certain demographic groups.

O'Hara et al. completed an investigation that sort to uncover the social underpinnings that surround the watching of television using mobile device.

To some extent their study findings, which were conducted in the UK, contradict the above. They found that users utilised mobile video in moments of isolation during their working day but also as a mechanism to appear engaged and to avoid unwanted conversations or difficult social situations when enjoying down time at work, or while travelling. Furthermore, that “content snacking” was not always the method of interacting with video on a mobile phone and users were also observed to watch for longer periods. This corroborates user expectation that the conventions of viewing content through a television set are shared when watching on a mobile.

Bentley & Groble (2009) detail a system that explores the use of mobile television while watching sporting events in a stadium or other arena. They describe the near-live delivery of multimedia artefacts, including user-generated video for spectators watching in the stadium. To augment the live spectating experience in the same way a television broadcast is enhanced by statistics and additional angles.

## USER-GENERATED VIDEO CONTENT

The previous section has discussed areas of work from HCI research that may help to inform second screen interactions that take place across multiple auxiliary display devices. Focus for the remainder of this review turns to issues regarding the second part of the thesis objectives; user-generated video content. As discussed in the previous chapter, alongside media multitasking user-generated content represents a further intervention in traditional television viewing practices. This intervention is particularly pertinent to this thesis interest in multiscreen television where several authors have investigated the confluence of companion applications and social media (Lochrie & Coulton, 2012) and the development of personalised companion experiences (Basapur et al., 2012). In addition, the focus on video content is framed by investigations into sports spectating that highlight the recording and sharing of video footage taken at sports events (Jacucci et al., 2006).

Web based content that is originated, produced and published by users has grown rapidly over recent years with the advent of computer based creative

tools and distribution platforms enabled by the social web. Collectively known as user-generated content, the creative endeavours of users can take on many different forms, including blogs, wikis, images and videos. User-generated content can also include metadata that retains the time of creation, location and other quantities relating to the artefact (Moens 2014).

“UGC denotes any form of content such as blogs, wikis, discussion forums, posts, chats, tweets, podcasting, pins, digital images, video and audio files and other forms of media.” (Moens, 2014)

A report of from the Organisation for Economic Co-operation and Development (OECD) (2007) provides a useful working definition of user-generated content as having to be published, creative and not produced using professional routines:

**Publication requirement:** user-generated content should be either available to all through the open web or to particular groups of friends, colleagues or family, which maybe achieved using social media platforms. These notions of publication and availability to groups of individuals are intended to discount other forms of communication, such as instant messaging and email, from being considered user-generated content.

**Creative effort:** User-generated content should involve a creative effort in its production, either through the development of new works of content or through the adaptation of existing works that may have been produced by other amateurs or professionals. The production of these digital artefacts could either be by individuals or by collaborating groups.

**Creation outside of professional routines and practises:** The content may not be produced by a professional organisation, such as a broadcaster or using the production routines developed for professional work to be considered user-generated content. The report notes the increased difficulty of maintaining this requirement as user monetise their output. A trend that has continued since the reports publication in 2007.

This thesis is principally concerned with user-generated video content. As a subset of the wider field of user-generated media, authors have examined the development and appropriation of amateur and crowd-sourced video from a number of perspectives, including the integration of user-generated and professional broadcast video (Hermida & Thurman, 2008) and narrative and the organisation and production of amateur video (Engström et al., 2012). In addition there has been some movement towards the appropriation of amateur content into sports broadcasting and dual screen television experiences. When taking and preparing video footage, user appropriation and creativity is a complex area of interaction, which has received little attention in existing literature (Kirk et al., 2007). There is contrasted by a relatively substantial body of prior work that has investigated the organising, editing, sharing and selecting of digital photographs (for example: Kirk et al., 2006, Shneiderman et al., 2006, Lindley & Monk 2006). Within Kirk et al., (2007) describe 'videowork' and the lifecycle of the amateur video, including the capture, editing, achieving and end use of video taken by individuals documenting their lives and activities.

Historically video content has been produced and distributed by a small number of traditional media companies, in the case of television, the expense, complexity and logistics of programme development was taken on by broadcasters. Viewers who watch user-generated content, do so for the same pleasurable and relaxing pursuits that users of professional broadcasts tune in for (Shao, 2009). With the advent of platforms such as 'Vimeo' and 'YouTube' users operate not only as content consumers but also as content producers, with interests that reflect those of traditional broadcast viewers. Image 2-4 shows the makeup of YouTube video views by genre in September 2007.

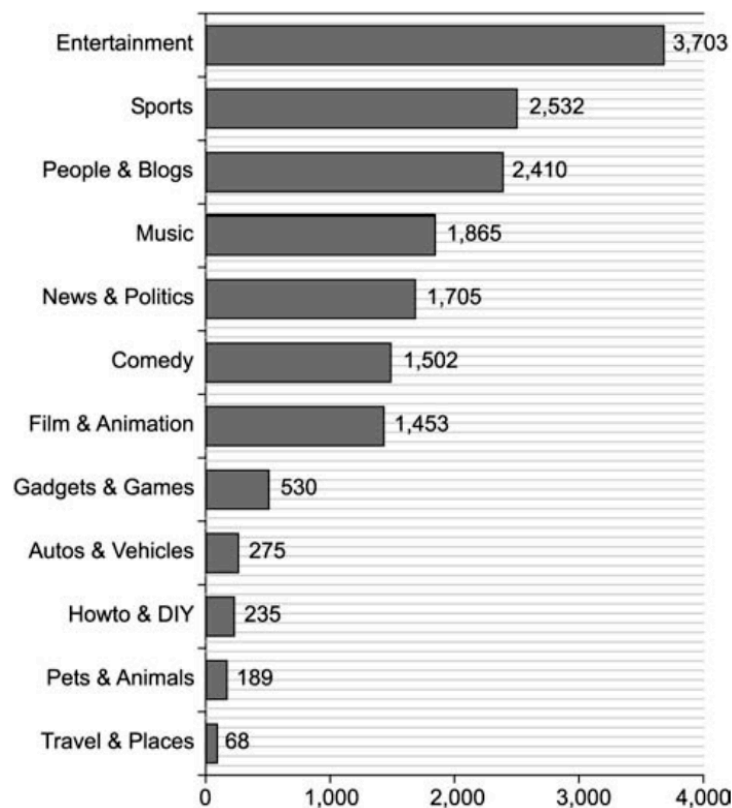


Image 2 - 4 YouTube video genres (cha et al., 2007)

Video content in standard Video-on-Demand (VoD) systems has been historically created and supplied by a limited number of media producers, such as licensed broad- casters and production companies. Content popularity was somewhat controllable through professional marketing campaigns. The advent of user-generated content (UGC) has re-shaped the online video market enormously. Nowadays, hundreds of millions of Internet users are self-publishing consumers. (Cha et al., 2007)

The above quote from Cha et al. (2007) highlights the challenges of producers remaining in control of output and audiences in an environment dominated by user-generated content. Hermida & Thurman (2008) present an in-depth description of the integration of user-generated content into printed news media in the United Kingdom. Their mixed methods study consisted of a series of surveys and expert interviews with newspaper editorial staff, and content analysis to measure adoption levels. While the article considers print journalism and the integration of textual user-generated content into the narrative, there conclusions may well be relevant to the issues of video. The authors summarise that previously sceptical news editors were increasingly



enthusied about the opportunities for user-generated content to be integrated into the development of journalistic stories. The editors saw themselves as “gatekeepers” integrating user-generated content while maintaining editorial control and moderation where appropriate.

Some commentators however, have seen the increase in use and availability of user-generated content as having a negative effect on traditional media. For example, Keen (2008) expresses deep dislike of the democratisation of content, bemoaning user-generated content as not containing the quality, culture or intellectualism of conventional professional content. He saves his most vitriolic comments for YouTube and its communities.

“YouTube eclipses even the blogs in the inanity and absurdity of its content. Nothing seems too prosaic or narcissistic for the videographer monkeys” (Keen, 2008)

### Sport And User-generated Video

In the prior section on mobile television, examples of smartphone applications for spectators of sports events were discussed. In addition to these broadcast examples, others have investigated the use of smartphone cameras as a mechanism for the capture of crowd-sourced video as well as replay. Jacucci et al. (2006) discuss the co-experience of groups of spectators’ videoing a motorsport rally. Within the authors detail a ethnographic study of a group day out at the rally, participants were asked to record their experiences through mixed media using mobile phones, including video and photography. The study revealed a desire not just to record and memorise the event but also to capture the social construction of the group. These activities were scaffolded by an awareness of the group and individual identity and the sharing of both digital content and social capital between participants.

The RunSpotRun mobile application is a further example of a sports spectatorship and is described in detail in Chapter Five (Flintham et al., 2015). The application, which I was involved in the development and evaluation of, allows spectators to video record their experiences of spectating a marathon using a mobile phone application. The application was

designed with a number of potential use cases for reviewing and re-watching the user-generated videos. While videoing, spectators ‘tagged’ runners by recording their bib number as they passed. The user-generated tags, the time and duration of the video, and the geolocation where the video was shot was attached as metadata providing a rich corpus of annotated video. The video footage generated using the RunSpotRun application was used in the development and evaluation of the MarathOn Multiscreen Application.

The confluence of second screen viewing and user-generated content is a relatively under explored area in the academic literature. As described above, in the section on academic research on second screen television, most of this prior work has focused on the integration of social networking statuses in ad-hoc media meshing. However one example, CoStream@Home (Dezfuli & Günther, 2013), describes the technical implementation of a multiscreen television application that integrates both broadcast video footage from sports events and footage taken in the stadium. The CoStream@Home system comprised of distributed components; a mobile app for spectators watching the match in person and a television application for those watching at home. The television application allowed users to switch between the professional broadcast and the user-generated clips from the mobile application. In addition, the television application integrated a Kinect sensor to allow the home user’s gestures to be reported back to users in the stadium. For example, if a user applauded a piece of gameplay seen in a user-generated clip, the applause would be sent back to the recording spectator as encouragement.

## FINAL DISCUSSIONS

Companion or dual screen applications are a subset of systems that allow users to interact with television programming. While some areas of interactive television have flourished as integrated experiences with the television, through electronic programme guides and smart TV services, others have received less attention and there are fewer examples of their implementation. The use of second screens has enabled a third path for the

development of interactive television applications. This has been achieved through the development of designed television experiences that take place across multiple devices and the ad-hoc appropriation by users engaging with other services while they are watching the television, such as Facebook and Twitter.

Dual screens have been described as adding interactive features to the television watching experience that allow users to “control, enrich, share and transfer content” (Cesar et al., 2008). These descriptions have been used to distinguish the cited work on second screens described within this literature review. This has included research into electronic programme guides (Cruickshank et al., 2007 and Park et al., 2006), Auxiliary content to enrich programming (Fallahkhair, 2005 and Murray et al., 2012), the integration of social platforms in television viewing (Doughty et al., 2012 and Lochrie & Coulton, 2012) and the use of screen mirroring (McGill et al., 2014). The majority of publicly available applications produced by industry have focused on creating enriching applications that often involve social sharing between geographically distributed viewers.

Companion applications are a small but growing area of interest for practitioners working in HCI. However, Work is yet to fully consider the wider implication of the collaborative and social aspects of viewing in a collocated environment. The first part of the thesis statement is concerned with the use of multiple screen television and its support for social viewing through content sharing and scheduling. Therefore, this literature review turned its focus to other sub-disciplines and areas of research from within HCI that considers the implications for multiscreen system design and other areas of television investigation, to add further grounding to the theoretical underpinnings that inform the design guidelines presented in the discussion chapter.

Practitioners working in the field of computer supported cooperative work have been concerned with the practicalities and deployment of groupware, involving both individual and multiple displays. These systems include

mechanisms to support collaboration by multiple users in the same location, such as “per-user feedback” (Bier & Freeman, 1991). Other insights into multiscreen HCI include the use of an ecological metaphor to describe the distribution and use of users and devices. Significant to the areas addressed in this thesis are display ecologies (Huang, 2006) that describe the interaction of multi display environment and how their use and appropriation changes over time. The majority of examples presented in the literature for these areas are framed by work practices and productivity. This is markedly different from the watching of television in the home, which is characterised by relaxation and engagement (Chorianopoulos & Spinellis, 2003). This thesis through the development of the design guidelines will be informed by the insights offered by this prior literature from CSCW and additionally mobile television, but will seek to further understanding of their implications in a different context and environment.

The majority of television is watched in the home, a challenging and complex environment to study that take researchers out of the comfort of the workplace (Hindus, 1999). While the studies conducted as part of the completion of this thesis do not take place within a domestic setting, the laboratory based observation trials were designed to reflect the interests of the environment. As described in the preceding chapter the design of study schedules was reflective of domestic qualities of fun, pleasure and engagement as described by Bell et al. (2003). In addition the studies conducted as part of this thesis, in particular the MarathOn Multiscreen Application evaluation, further challenges notions of television watching being a ‘lean-back activity’ (Barkhuss & Brown, 2009) involving complex and sustained interaction with video and programming.

The second part of the thesis statement is concerned with the integration of many-screen viewing where users interact with a configuration of companion devices and user-generated video content. The second study that is considered in chapters Five and Six, MarathOn Multiscreen sits at the intersection of the literature on second screen viewing and other multiscreen

insights, and that of crowd-sourced video content. This literature review has provided a definition of user-generated content that highlights the attributes of publication, creative effort and creation without professional routines and practices (OECD, 2007) and discussed its integration with professional content (Hermida & Thurman, 2008). The evaluation of the MarathOn Multiscreen Application will inform multiscreen television literature on the integration of user-generated content with professional broadcast, extending beyond understanding of social media.

## CONCLUSION

This chapter has identified a range of HCI literature relevant to the thesis focus of multiscreen television viewing.

Second screen television literature has identified the sociality of television viewing both with interactions between remote viewers (Lochrie & Coulton, 2012) and those watching at home together (Cruickshank et al., 2007). However, little work has been done delving into collocated interaction of groups of viewers. The studies presented in this thesis address this gap with user investigations of two probe applications. Several second screen studies have incorporated the use of user generated content in the form of social media updates (such as, Doughty et al., 2012 and Basapur et al., 2012) these notions will be extended to look at the special case of user generated video content, which has yet to be studied in the context of second screen viewing. In addition, this dissertation will draw on a range of other literature from HCI paradigms to inform its findings. Significantly, CSCW notions of groupware and mobile television practices.

The next chapter discusses the Internship with BBC Research and Development and the design of the Olympic Companion Application.

# CHAPTER THREE

## *Designing the Olympic Companion*

### *Application*

#### INTRODUCTION

This chapter discusses the design and development of a many-screen application that allow users to view highlights of the London 2012 Olympics across a multiscreen ecology. The application was developed during an industry placement with BBC Research and Development at MediaCity UK, this period of immersion directed the development of the app along current industry thinking and techniques.

In this chapter the details of the internship will be discussed, followed by a description of second screen applications that have been developed by the BBC, both for deployment to the public to enhance broadcast television programming and as research prototypes and probes. This section builds on the industry and academic work into multiscreen television discussed in the previous chapter with focus on examples and insight from the BBC that further helped to inform the design of the Olympic Companion Application.

In the second half of the chapter, the design of a prototype second screen application is described. The application allows collocated users to watch highlights of the 2012 London Olympics, across an ecology of companion tablet devices and the television. While using the application viewers can engage with multiple simultaneous channels of sports events on different devices, review event statistics, and control the television from the application.

## INDUSTRY ENGAGEMENT

The Olympic Companion Application was developed during a period of immersion in a corporate setting in order to foreground industry relevance and current practice. I undertook a three month internship with the BBC Research and Development department's (BBC R&D) North lab at MediaCity UK in Salford between October and December 2012. During this period the Olympic Companion Application was conceived and initially developed. Among the current projects being conducted in the lab there is an active interest in the design and development of companion applications by user experience, networking and interaction technology specialists. This interest has led to the development and evaluation of several multiscreen applications, including the 'AutumnWatch' and 'Secret Fortune' applications. In turn this has facilitated the development of the Universal Control API for standardising interactions between DVB and networked devices.

To some extent the research questions and thesis statement presented in Chapter One. is informed by the internship at BBC R&D. While design guidelines are a typical method for disseminating research finding to an HCI audience, the format is useful to practitioners working in both research and product environments in organisations like the BBC. Therefore, it is hoped that presented the key findings through a series of descriptive guidelines makes them accessible to the television industry. The first research question considers how users share content across an ecology of devices and is in part informed by the BBCs interest in scheduling multiple feeds. This interest is grounded in the experiences of broadcasting the Olympic games in the

summer of 2012, where users were engaging with multiple sports events on different platforms at the same time. The Olympic Companion Application provides a single platform for users to move between feeds and events.

The development process of the Olympic Companion Application was articulated through a series of informal discussions with both sports producers and software developers working in BBC R&D and BBC Future Media Sports Product, which provides the BBC's digital media services for sports broadcasting. These include mobile applications, BBC Online's sports content, and 'red button' services for digital televisions. The purpose of these discussions was (a) to investigate what second screen developments and application types would be of interest to the BBC, and (b) to establish relationships that would allow for an on-going partnership throughout the design and evaluation process.

#### The British Broadcasting Corporation

The British broadcasting corporation was established as a public service broadcaster in 1927. A prior organisation bearing the name BBC was founded previously, in the early 1920s, as the sole licensing organisation of the UK's radio frequency. The values and commitment of the corporation as an impartial public service broadcaster were enshrined with the establishment of the first royal charter in January 1927 (Briggs, 1961). The current royal charter, which is valid between the years 2006 and 2016, includes the BBC's mission and purpose. Referencing a quote by Lord Reith, the BBC's first director general, the mission states that the BBC's function is to "inform educate and entertain" the citizens of the United Kingdom with high quality television and radio broadcasts, and online services that promote the public purposes of the organisation (Secretary of state for culture media and sport, 2006a).

"The Public Purposes of the BBC are as follows—

- (a) sustaining citizenship and civil society;
- (b) promoting education and learning;
- (c) stimulating creativity and cultural excellence;
- (d) representing the UK, its nations, regions and communities;
- (e) bringing the UK to the world and the world to the UK;



(f) in promoting its other purposes, helping to deliver to the public the benefit of emerging communications technologies and services and, in addition, taking a leading role in the switchover to digital television.” (Secretary of state for culture media and sport, 2006a)

Today, the BBC is the largest, most trusted (Sehgal, 2009) and arguably best-known public service broadcaster in the world. Each week 96% of the UK adult population consume BBC content across all platforms. These viewers, listeners and readers spend an average of 18.5 hours a week engaged with radio, television and online services (BBC Annual report 2013/14, 2014). The BBC’s biggest programmes or “superbrands”, such as ‘Strictly Come Dancing’, ‘Doctor Who’ and ‘Top Gear’, (BBC Worldwide, 2013) are known the world over.

As a public service television broadcaster the BBC has a different relationship with its viewers than that of their commercial counterparts. A licence fee that is paid by all viewers of UK television annually principally funds the BBC. Therefore, its programmes do not contain advertisement breaks or product placement. Commercial broadcasters, such as ITV or BSkyB, assess their viewership not only by its volume but also by its quality. It is advantageous to the commercial broadcaster to attract viewers, who are likely to be affected by advertising and have disposable income to spend on advertisers products (Holland, 1997). The BBC, conversely, is motivated to keep its audience share high to justify the licence fee, which regularly comes under public scrutiny and at times has been seen as a contentious means of funding the corporation (e.g. Toynbee, 2003). The lack of need for advertising revenue not only ensures the relevance of its programming schedule to breath of the population of the UK, but also enables niche programming to be developed and explored without commercial sensitivities. However, It should be noted that the BBC has a commercial sister organisation, BBC Worldwide. Part of the responsibilities of BBC Worldwide is to sell programming to other broadcasters around the world. Increasingly this has become an important part of the BBC’s public service funding and conceivable that programming is in part commissioned and developed with a view to international sale to commercial broadcasters.

The BBC is a compelling location to engage with the television industry as a research partner, with opportunities to develop technologies and explore application areas not possible in the commercial arena. The BBC is committed, through its royal charter, to engage with emerging technologies and services to deliver new broadcasting technologies to the public, without the commercial requirements of those working purely in the private sector. It is this requirement, by agreement between the BBC and the UK government that has established BBC Research and Development department (abbreviated to BBC R&D) (Secretary of State for Culture, Media and Sport, 2006b). It could be suggested that developing a relationship with a public service broadcaster, with the unique funding, constitution and cultural position of the BBC limits the impact of research findings. Restricting results applicability to other broadcast institutions and the international relevance of the work. Unlike its commercial counterparts the BBC has a commitment to investigate new technologies as part of its charter since the corporation's inception. Additionally, the BBC's work does not exist in a vacuum of public service broadcasting and needs to remain competitive with the wider television producing community in the UK and abroad. However, it should be noted that design decisions and study direction for the Olympic Companion Application, are guided by the needs of a public service broadcaster and do not consider the requirements of a similar application from a commercial institution, such as the use and value of a second screen application for advertising.

### BBC Research and Development

The BBC's first research department was founded in 1927 at the same time as the corporation's royal charter was established. The department's current incarnation is known as BBC research and Development and has three laboratories, two in London and the other in Salford. The department has been at the forefront of audio and video transmission research throughout its history, including, playing key roles in the development of transatlantic satellite communication, digital video broadcasting, Teletext services and the launch of the BBC's online services in 1997.

In 2011 R&D North Lab was opened as part of the BBC's move out of BBC Television Centre in west London. North Lab is positioned within MeidaCity UK a large development in the Salford Quays designed to reinvigorate an industrial part of the north west and to offer lower cost office and production space to broadcast companies than are available in the nations capital. As well as the establishment of R&D North Lab the BBC has relocated the sport, Radio 5 Live and Children's departments, and various technical support infrastructure to the facilities. The location of these departments meant that during period of my internship I was able to access professionals working on a variety of BBC outputs, however most significantly to the development of the Olympic Companion Application was the opportunity to engage with producers and technologist working on sports output.

#### Internship with BBC R&D

BBC Research & Development were approached to host my internship due to this extensive experience of multiscreen applications and their interest in maintaining a research agenda for their development and evaluation. Initial contact and communication were arranged through existing research partnerships between BBC R&D and the University of Nottingham. Fortuitously they were keen to prototype and investigate the potential of second screen technology through an internship. The internship was undertaken with the intention of achieving two goals during my time working at BBC R&D; (a) immersion in the BBC's research culture, to understand the requirements, tools and interests in second screen applications by industry, and (b) the design and development of an initial prototype of a companion app, based on the understanding developed by the first goal.

The development of the prototype application, allows for gaining insight into the process of designing and building a companion application that is capable of working across multiple display devices. In addition, the resulting application provides a vehicle for the subsequent user study that addresses the first research question set out in Chapter One.

In the next section relevant BBC second screen applications are discussed, these applications include publically deployed and research developments.

## EXISTING BBC APPLICATIONS AND PLATFORMS

Part of my initial activity while interning at BBC R&D was to investigate applications and platforms the BBC had developed as part of their explorations with multiscreen television. This process helped to inform the first internship goal from above. In this section many of the second screen applications developed by the BBC for both research and deployment are discussed. This list has been updated to include newer applications deployed since the period of the internship.

Over recent years the BBC have produced a number of companion application experiences, both as research prototypes and publicly deployed apps. Senior figures in the BBC's management have expressed the value that second screen applications bring to television programmes and a desire to ultimately have some form of companion experience for each BBC television programme. (Moulding, 2012). BBC's Future Media division, responsible for all BBC's online and interactive content, have a four screen strategy to describe output across devices. The four screens are defined as, connected television, tablet, mobile and PC (Rivera 2011). The development of a second screen policy is seen as introducing connectivity between these existing services (Moulding, 2012). The following subsections detail key companion experiences that have been built by the BBC. The first subsection discusses publicly available applications and is followed by experiences built for research and piloting. This section is concluded with a discussion of a platform built by BBC R&D for the development of 'orchestrated media' across connected devices, Universal Control.

### Public Applications

#### ***Antiques Roadshow***

The 'Antiques Roadshow' application was launched in January 2012 and was the BBC's first publicly available second screen companion app. In the

programme, members of the public bring their antiques, collectables and heirlooms to the Roadshow, where they are described and valued by experts. The application allows viewers to play along with the expert valuation, for each item discussed on the television screen players are presented with three valuation choices. They have the time it takes for the expert to describe the objects provided to make an estimate of its price (Williams, 2013). The application was designed as a companion version of an existing 'red button application' accessed through interactive TV services. The application operates as a standalone experience, users cannot share their scores with one another digitally. However, social media responses to the application show it to be a social experience in the living room, with friends and family playing along together, comparing scores as well as posting them to social media services, such as Twitter (Bedwell, 2013).



Image 3 - 1 The Antiques Roadshow Application (Williams, 2013)

The 'Antiques Roadshow' application connects to the television using an audio watermarking system. Audio watermarking places a hidden echo in the audio stream of the programme undetectable to human ears. However, the echo can be detected by an electronic microphone and interpreted as timestamps related to the programmes playhead. Traditionally these techniques have been used as a hidden means of securing digital media from piracy and copying, with unique hidden codes signifying a particular piece of content (Oh et al., 2001). The echoes are placed at various locations

throughout the duration of the programme and allow the listening application to stay in synchronisation with the broadcast. This system has an advantage over a broadcast synchronisation system, such as that used by 'The Voice' application, allowing viewers to pause the programme, record it to a PVR or watch on the BBC iPlayer catch-up service, while the application remains in synchronisation with the programme on the television.

### ***Gory Games***

'Gory Games' is a children's quiz show based on the books and television comedy 'Horrible Histories'. Studio contestants taking part in the quiz answer questions about historical events and people. The application allows viewers to play along at home, answering the same questions as the studio contestants, and comparing their scores with friends and those who took part in the broadcast. The application synchronises with the broadcast using the same audio watermarking technique as the 'Antiques Roadshow' Application (Gory Games, 2014).



Image 3 - 2 Gory Games Application (Gory Games, 2014)

### ***The Voice UK***

'The Voice UK' application supports social interaction and play along with the broadcast of the Saturday night talent show. In the programme aspiring singers are invited to perform for celebrity judges. The Voice's twist on the talent show format is that when judges first hear the contestants sing they are unable to see the performer, they must make a judgement based on voice alone. Singers selected to take part in the later rounds of the competition are

then coached by one of the celebrity judges for the remainder of the series, each week singers are eliminated before a winner is declared. The application provides users with additional content, and a portal for engaging with social networking updates about the programme and sharing opinions with friends. In addition, the application allows viewers the opportunity to pass judgement on singers during the broadcast and see if their opinions match those of the celebrity judges (The Voice UK, 2014). Unlike the 'Antiques Roadshow' and 'Gory Games' applications, 'The Voice UK' does not use audio watermarking to keep in synchronisation with the programme. The application runs in Synchronisation with the programmes broadcast on BBC One. This means that viewers cannot pause the programme or watch using a catch-up service and still be able to interact with the application as if they are watching live. This appears to be a necessary design decision when considering the applications heavy reliance on other social media platforms. Applications offering similar functionality are available for ITV's competing programmes, 'The X Factor' and 'Britain's Got Talent'.



Image 3 - 3 The Voice UK Application (The Voice UK, 2014)

### Research and Internal Pilot Applications

Attention is now turned to applications that have been developed as part of research activity by BBC R&D. Research conducted by the laboratory is made publicly available through the publishing of blog posts, and white papers describing technical implementations and study findings. In addition work is disseminated to the academic community through journal and conference publications.

### *Autumnwatch*

BBC R&D developed and studied a companion application for the nature programme 'Autumnwatch'. 'Autumnwatch' is one of several magazine programmes, which chart British wildlife through the changing seasons. The programmes format relies on contributions from viewers, who are asked to report on animal activity in their gardens and communities, and encourages engagement in conservation charities and campaigns. The companion application takes the form of a broadcast synchronised slideshow, which updates with additional facts about the main television content. For example when the presenters introduced a section on flocking starlings, the second screen application showed information about the swarming behaviour of Starlings (Ferne, 2010). The application synchronised with the broadcast using a publisher/subscriber messaging pattern and the XMPP protocol, which ensured page updates were made at the same time as the content was broadcast. Similar to 'The Voice UK' the 'Autumnwatch' application was not designed to work with catch-up services or PVRs. The application was evaluated alongside the programmes broadcast by around 400 participants watching at home. In a blog post on the BBC R&D website Jones (2011) discusses the findings of the study, user opinions were gathered through questionnaire responses at the end of the programme. The study uncovered that while users found the content to be engaging and increased their understanding of the programmes topics, interaction with the content could be distracting and even inducing anxiety when users feared missing parts of the main programme. In addition, the exercise demonstrated that producing relevant companion content for a live television programme is a very



challenging activity, keeping up to date with the changing content, up until the programme is broadcast, can only be done from within the production team.

### *Jigsaw*

The Jigsaw application was designed by BBC R&D as a prototype application for supporting intergenerational interaction with television programming. The application allows viewers to 'snap' a screenshot of the television programme to the tablet application. This could be an image that appeals to a young child in a more grown up programme, such as a nature documentary, while watching with other family members. The application turns this image into a Jigsaw, which they can complete while other family members watch the programme. Jigsaws can be made of various difficulty levels, depending on the age of the child or opportunities for adult help. The application was built following in-depth ethnographic studies of how multiple screens were integrated into television viewing practices by 12 families over the course of a month. Data was collected from interviews and diary studies. The application was developed during a workshop that considered the findings of the ethnography with relation to natural history programming.

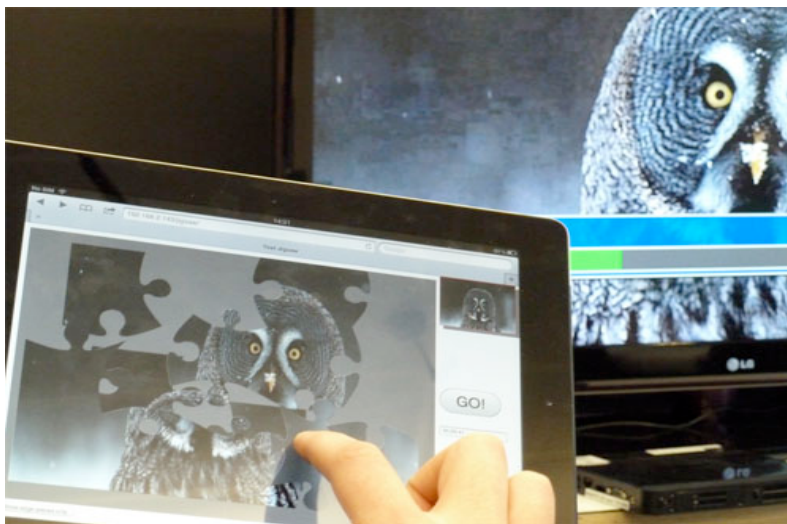


Image 3 - 4 The Jigsaw Application (Courtesy of BBC R&D)

The application was evaluated in a laboratory based user study at the BBC R&D labs, with parents and children, the study provided user groups of

between two and three with two tablets, without instruction on how the tablets should be divided between the participants. At the time of writing the application, ethnographic study or user study, have not been published in either academic or industry literature.

### ***Secret fortune***

‘Secret Fortune’ was a quiz show attached to the Saturday night lottery draw programme, in which contestants could win up to £100,000 by correctly answering multiple choice questions and choosing from a collection of sealed envelopes. Similar to the publicly deployed ‘Gory Games’ app the companion application experience allowed viewers to play along at home using a tablet or smartphone. The application was evaluated in a closed public trial to around 200 participants, looking at its use by viewers at home and to test the synchronisation API (Jolly, 2011a). In a presentation to industry and media journalists Victoria Jaye, head of Head of IPTV & TV Online Content at the BBC, made the following comment about the social implications uncovered by the user trial of the secret fortune application:

“What the audience told us about Secret Fortune is that it is all about playing together,” she revealed. “It was clear that ‘social’ can mean simply playing together in the living room but people also have a sense of togetherness with the nation. They said the experience was much more fun live rather than on-demand.” (Moulding, 2012)

The ‘Secret Fortune’ app made use of the Synchronisation API (Jolly, 2011a). The API allows the application to be switched between different synchronisation methods based on their availability and maintaining the best user experience. For example if the application were unable to hear Audio watermarks, it would automatically switch to listening for publisher/subscriber messaging. Trading off the reliability of messaging against the flexibility of watermarking, if the user has paused the programme they will be out of synchronisation, however for most users watching at the same time as the broadcast, the experience will be uninterrupted. In addition, the Sync API provides an abstraction layer between an application and the underlying technology communicating with the television, therefore

applications can be updated to new and emerging technologies by updating the API's implementation and retaining the same application code base.

### ***Universal Control Platform***

In addition to the applications discussed above, the BBC has been involved in the development of the underlying platforms and infrastructure to support the development of second screen companion applications. One of the innovations developed by researchers at BBC R&D is the Universal Control API (Application programming interface).

The API provides a restful interface to a DVB (digital video broadcast) receiver, returning programme and state information, such as the current programmes title and playhead position, and the ability to control the television from connected smart devices and computers (Barrett et al., 2011). Universal Control is designed as a response to the increase in network connectivity of modern televisions and media playback devices, such as set top boxes, Blu-ray players and games consoles. The Universal Control API is designed to enable what is referred to as 'Orchestrated Media' by BBC R&D. Orchestrated media is described as "experience of interaction, synchronisation, and collaboration of programme and companion content across devices" (Kramskoy, 2011). This includes enabling synchronised interactive experiences with programming, interfacing with Social media and migrating content between the television and companion devices. The API offers several possibilities to the development of second screen applications and orchestrated media that would have not been possible with the technologies discussed previously in this section. Universal Control creates a connection between television and smart device, which does not rely on the viewer sticking to the broadcast schedule as required with broadcast synchronisation or using a messaging system, similar to those implemented by 'Secret Fortune' and 'AutumnWatch' applications. In addition, it is more reliable and lower cost than audio watermarking techniques. In a blog post Jolly (2011b) describes the technical advantages of using the Universal Control platform, as enabling a complex array of interactive experiences and customisable and accessible remote control applications.



Image 3 - 5 The Universal Control Dalek (Woolard [still from embedded video], 2011)

One particularly interesting development is the deployment of Universal Control clients in to embedded computer systems. This has been demonstrated by the development of a robotic toy 'Dalek' from 'Doctor Who'. The Toy is activated by the programmes broadcast reaching a certain playhead, it proceeds to mimic the onscreen Dalek's behaviour and says its dialog, in synchronisation with the programme (Woolard 2011).

The initial implementation of the Olympic Companion application was completed in Universal Control, however subsequent iterations replaced Universal Control with AJAX long polling techniques, to improve stability for user testing. The details of the application's implementation and technical decisions are discussed in detail in the Application Design section of this chapter.

## APPLICATION FOCUS

The following section discusses the design focus of the Olympic Companion Application that addresses the second internship goal defined earlier in this chapter. The design of the Olympic Companion Application is informed by several of the applications and platforms discussed above, and through the period of immersion in BBC R&D.

### Sports Programming

Discussions with representatives of BBC R&D prior to the start of the internship, included negotiations about which genre of programming would

best fit the department's and my interests in second screen television applications. In their description of genres most suited to augmentation with additional social components Geerts et al. (2008) suggest that with synchronous experiences, such as those offered by companion applications, news, soaps, quizzes and sports programmes are best suited to augmentation. These genres formed the start point for our discussions, however it was determined that the complex overarching narratives offered by sports and news broadcasting were best suited to the social emphasis of this thesis, allowing users to have opinioned discussions about programming, to augment video content with additional information and context, and offered a greater range of possible interactions for investigation.

During the internship, I was posted to R&D's laboratory at MediaCity UK in Salford, which is also the location of BBC's Sports department. Along with support for the choice from R&D, this determined sports programming as the genre of interest. From the BBC's facility in Salford, the majority of sports content is produced across all medias of interest. This includes Online, BBC's sports Radio channel, BBC 5 Live, and television programmes such as 'Match of The Day'. Across the year BBC Sports outputs almost 2000 hours of television programmes (not including on-line live streaming) and 5000 hours of radio.

### Application Requirements

During the initial weeks stationed at the BBC the first of the two internship goals was the primary focus. This goal centred on investigating the BBC's expertise and tools for developing second screen applications, and their interests in companions for sports broadcasting. A series of informal meetings were conducted with software developers, some of which had been involved in the development of the Universal Control API, and user experience researchers working on second screen applications from R&D. In addition I was afforded the opportunity to meet and discuss my prototype ideas with producers from Future Media's sports division.

Following these discussions, with both R&D and Future Media, the following requirements were developed to guide the development of the application. The requirements are also shaped by the BBC's existing portfolio of companion applications and tools, where applicable these comparisons are detailed below:

***Orchestrated Media:*** The principles of what BBC R&D refer to as 'Orchestrated Media' (Kramskoy, 2011), were of significant interest to the development of companion applications at the time the internship. The concept suggested several principles that the application's interaction should adhere to. First of these principles is that interaction can take place across devices, therefore users could start doing something on one device and be able to pick up on another. Second, that the television can be controlled from the tablet application, replicating the functionality of a remote control. Implementing the application using Universal Control could enable this functionality with current television standards. Finally, the application can operate in concert with programming on the television and offer synchronised content on the companion devices, this enables the second requirement, programme content augmentation.

***Programme Content Augmentation:*** Offering similar programme augmentation as the 'Autumnwatch' application described above, the prototype application should provide functionality to augment television programming with additional content that enhances the users knowledge and insight into the main broadcast.

***Sociality of TV Watching:*** In line with the focus of this thesis, the application should exploit the sociality of the collocated environment that epitomises television watching. Similar to the interactions that were reported from the deployments of the 'Secret Fortune' and 'Antiques Roadshow' applications. However, with the focus on sports programming, the intended sociality would focus on sharing of facts and figures, and organising what content to watch on which devices.

**Utilises Universal Control:** BBC R&D were keen to develop further demonstration prototypes and examples using the Universal Control API. The initial version of the Olympic Companion Application was built using the technology and subsequent versions functionality could be engineered using it.

### The Olympics

A key decision taken during the initial phase of the internship process was determining the programme or sports event that would be the focus of the application. The internship was conducted in the autumn of 2012, shortly after the BBC had broadcast the Olympic games to both critical praise and significant public demand. At peak times during the Olympiad they had broadcasted 24 simultaneous feeds and their coverage during the games was watched by 90% of the UK population. I took this as an opportunity to engage with the possibilities around a multisport tournament, where the action unfolds concurrently across a number of different events. Therefore an application was built that would allow for the watching of highlights of the Olympic games across a number of devices, while also supporting additional statistics synchronised with the video programming.

“The benefits to audiences of the BBC’s investment were clear during the Olympics. The Trust approved the plans to launch temporary Olympic services and extend online coverage including through 24 video streams. This extended coverage, providing some 2,500 hours of live sport, was watched eagerly. The BBC received 12 million requests for video on mobile as well as 9.2 million browsers accessing the dedicated mobile site and Olympics app over the course of the Games” (BBC Trust review and assessment, 2012).

The decision to use the Olympic games as a scenario for the prototype application was supported by BBC R&D and Future Media departments. They saw the context as potentially fostering internal engagement with the prototype, as the usage data from the digital distribution of the games programming were widely distributed within the organisation. In addition, the corporation was interested in new approaches to take forward their coverage for future events.

As discussed in the introduction chapter of this thesis, the decision to use an event that has already taken place is grounded in the practicalities of integrating a prototype and user study into the broadcast chain and augmenting live programming with additional second screen content.

## APPLICATION DESIGN

This section describes the design and development of the Olympic Companion application in detail. It begins with a discussion of the application's features and main functionality. This is followed by a comprehensive walkthrough of the application in use and concludes with an outline of the video and additional content that was used by the application during the user study.

The application was designed to allow a collocated group of viewers to watch several Olympic sport events simultaneously across multiple tablet devices and a television. The application also allows users to switch content between these devices, continuing to watch a video started on the tablet on the television from the same playhead. This functionality permits users to dynamically schedule their viewing across the ecology of devices as a group, switching content to the television when particular parts of the programme are of interest to the whole group and resuming on the tablet, when it is of interest to just a single member. In addition, the application augments the video content with additional facts and figures about the programme content, including, athletes biographies, news articles, and event results and statistics.

### Prototype Version

The initial, prototype version of the application, was conceived and built while resident at BBC R&D, following discussions with practitioners and researchers involved in sports broadcasting and second screen application development. The application was built using HTML 5 web technologies and initially communicated with a television using the Universal Control platform (Barrett et al., 2011). BBC R&D provides a demonstration version of Universal Control built as an extension to 'MythTV', a Linux based media centre which supports DVB (Digital video Broadcasting) adapters. Therefore UC can



integrate with television programming from the BBC and other broadcasters. In the case of the Olympic Companion application MythTV's ability to playback pre-recorded videos was used to view highlights of Olympic events. The Olympic Companion Application is designed to contain the following functionality, which is grounded in the application requirements discussed above:

***Download a schedule of programming:*** At the start of execution the application connects to a server (written in Node.js), from which it downloads a schema of television channels. Each channel contains a name, thumbnail and short description to present to the user. In addition channels also contains a URI to the video file for the channel and a list of html described statistical update pages. Each update page includes a video timestamp, the application only makes the page available when the video playhead on either the tablet or television has exceeded it.

***Watch programming on both the tablet and the television:*** The application presents users with the selection of channels that have been extracted from the schema, users can then choose to watch these channels on either the tablet or the television. Users can select to watch channels either from the start of the programme, to watch the programme live or to pick up where they had stopped watching previously on either the tablet or the television. Allowing the user to resume watching at the correct playhead and on a different display, meets the cross device requirements of orchestrated media. To implement the live functionality the application mimicked the notion of a broadcast by each channel having a 'live playhead'. Unlike a regular playhead, which increases with user progress through a video. The live playhead charts time passing. Therefore if a user selects to watch a particular channel live, the video starts playing from the live playhead. As an example if the user selected to watch a channel live 10 minutes into a user trial the video would start playing from 10 minutes in.

***Control the television from a second screen:*** The Olympic Companion application allows the user to pause rewind and fast-forward the video.

However fast-forwarding is only an available option when the user has rewound the programme as would be expected from a PVR on live broadcast television.

***Augment video programmes with statistics and other relevant information:***

Each of the available programmes of highlights has an associated feed of statistical updates about the events in the video. These updates are available to users on the second screen app, and only available after the event has been watched on the television or the tablet. However, users were able to unlock this restriction and to see ‘spoilers’ about events that they were yet to watch.

***Multiple second screen applications could be connected to the television:***

The system is designed so that any number of second screen application instances can be connected to the television. However, in the user trial discussed in the following chapter, users had access to between 1 and 3 second screen applications at a time.

***Log User Interactions:*** All user interactions with the application are sent to the server and saved to a log file, these logs aided in the user analysis of the application.

***Alternative interaction with a remote control:*** The usability of the companion system is enhanced with the addition of a remote control. This component allows users to interact with the television in the traditional way, selecting their preferred channel to playback from the live playhead, when using the remote control users are not afforded the opportunity to resume or start the programme from the beginning. The inclusion of the remote replicates familiar functionality and highlights the differences in controlling the television with a remote control and the application. For ease of implementation and integration with the rest of the system this is designed as a smartphone application using HTML5.

***Broadcast Schedule of programming:*** The application is designed to simulate the broadcast of an unfolding schedule of content; therefore channels could

be started at different times during the user trial. While this feature is simulated in the application's implementation, it replicates the real life experience of watching the Olympics where events and highlights unfold over the days and weeks of the games. This feature allowed for the content to be timed so that key events would coincide with each other on different channels forcing users to make scheduling choices. A timestamp field was included in the channel schema, downloaded at runtime; this enables the applications to schedule the availability of programming.

## USER STUDY ENHANCEMENTS

Following the period at the BBC several enhancements were made to the application prior to it being evaluated by users. Mostly these changes involved the removal of bugs and addressing stability issues, in addition to improving the applications visuals and nomenclature. The application was redeveloped to not make use of the Universal Control API, the rationale for this choice and the revised implementation is discussed in the following subsection. The changes were presented to the practitioners I had worked with at the BBC during the internship, for validity with their second screen interests and industry relevance.

### *Revised Architecture*

The most significant change to the application, after the demonstration version developed whilst resident at BBC R&D, was its redesign and code without the use of Universal Control. The demonstration version of UC, implemented using MythTV, proved not stable enough to be used by evaluating users. Instead the application communicated with a server using AJAX (Asynchronous JavaScript and XML) long polling techniques (Gutwin et al., 2011). A separate TV application was also design and developed using web technologies. The TV application communicated with this server in the same fashion, waiting for control signals from the connected instances of the application. From here onwards the components will be referred to as the tablet application, television application, server and remote (discussed below). The technical implementation of the revised system is discussed below for completeness, allowing other researchers to recreate the

application accurately. The approach described proved to be an effective, lightweight prototyping mechanism for companion applications, however is limited in structure and therefore was inefficient in reuse and improvement. These issues are addressed in the reusable code base described in Appendix A, developed as part of the MarathOn Multiscreen Application.

AJAX long polling allows for an HTTP request between server and client to be held open for an extended period of time (normally in the range of 10-30 seconds). This request is only answered if the server has new data to send to the client, otherwise the connection times out and a new request is opened immediately. This allows for server and client to be in continued communication over HTTP with minimal request overhead. Image 3-6 shows the connections between the components of the Olympic Companion Application. Solid lines represent normal requests, where a response is expected as soon as is possible, and dotted lines long polls. The long poll requests are used by the television application and instances of the tablet application, when new the server makes information available. For example, if a user running an instance of the tablet application, taps the television pause button a normal HTTP request is sent to the server, the sever responds to the open long poll request open on the television application with a message indicating the television should be paused and the television instigates the action. Finally the server checks if any other instance of the tablet application are connected and responds to their long poll request with a notification that the television has been paused. These instances can then update their internal model that the television has paused, preventing the display of any new statistical update pages and switch the television control button to show the play icon.

While the Olympic Companion Application is no longer implemented using Universal Control, all the functionality, including the enhancements discussed here, would still be implementable using the API.

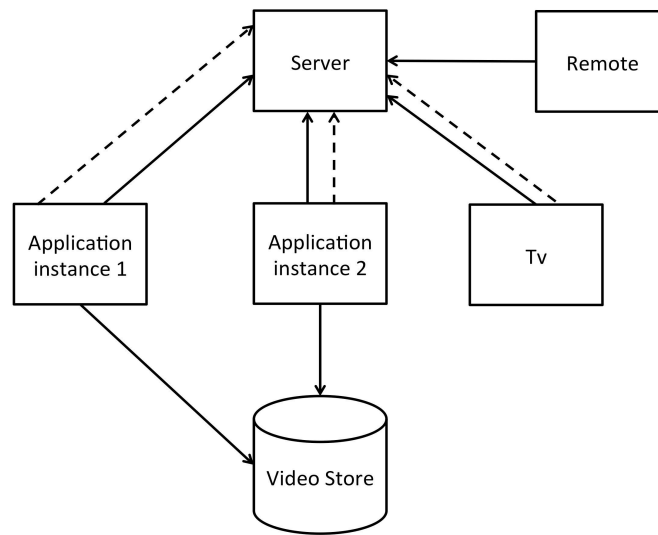


Image 3 - 6 Olympic Companion System Architecture Outline

Communication between the remote control application and server was also conducted by HTTP AJAX requests, however, no long polling was required, as the remote did not need to respond to requests from other devices.

### Application Walkthrough

This section steps through the experience of using the Olympic Companion tablet application and the remote control application. Core functionality, visuals and dialog boxes are illustrated through screenshots of the applications in use.

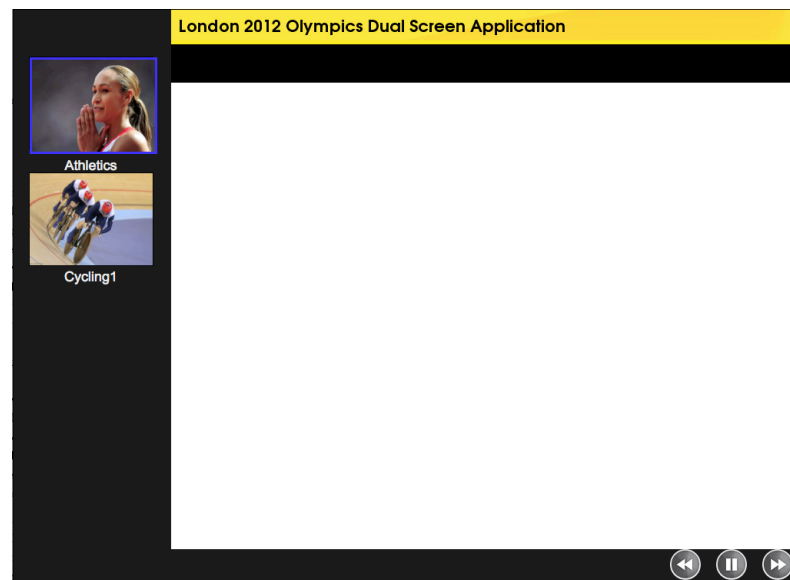


Image 3 - 7 The Olympics tablet application upon launch

Image 3–7 shows the tablet application as it is presented to the user when first opened. The area on the left hand side displays the channels that are available for users to select from. During the course of the study more channels are broadcast and added to this list as described in the following section, Application Content. For example, after 20 minutes, the rowing channel is added to the list. Channels are not removed from the list when the broadcast ends, instead the live playback option is no longer available. The three control buttons in the bottom right of the screen shot, allow the user to control the television from the tablet application. From left to right these buttons are, rewind, play or pause (depending on the television's current playback state), and fast forward. The controls are only visible on screen when content is playing on the television.

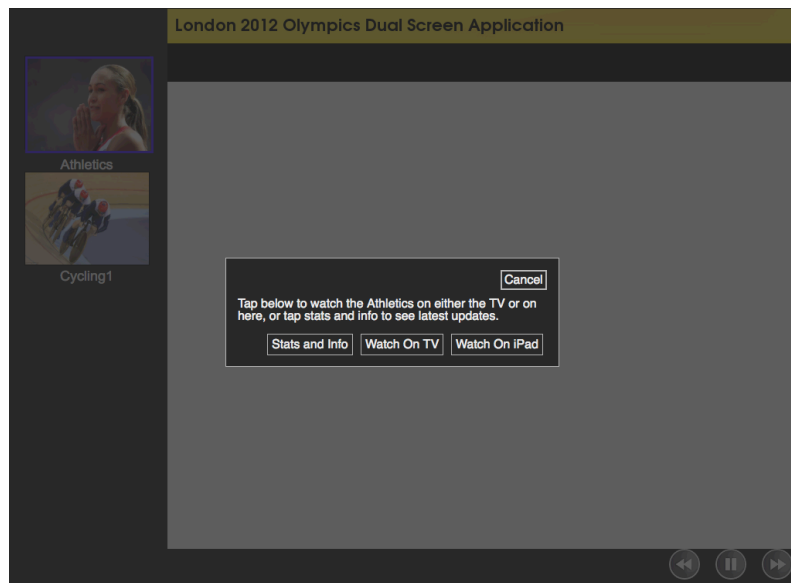


Image 3 - 8 the playback dialog box

Upon selecting a channel from the list users are presented with the playback dialog box, offering three options to access channel content (Image 3-8). The first option, stats and info, displays auxiliary content about the programme. The second and third option, watch on TV and watch on tablet, start playback of the programmes video on either device. Selecting either of the video playback options from the dialog box brings up a further dialog box with options to determine the playhead location to commence playback from. The playhead location options are displayed based on whether the channel is currently available to watch live, or whether the user group has already watched some of the broadcast and can resume from a prior playhead. Table 3-1 enumerates each of the different options available, these options are the same regardless of whether watch on television or tablet was selected by the user.

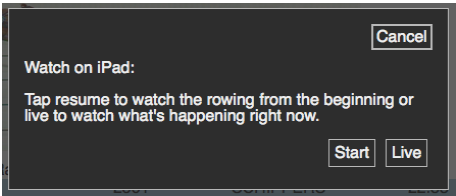
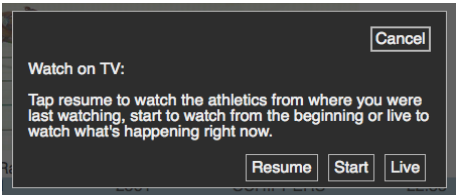
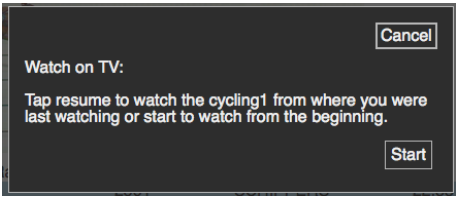
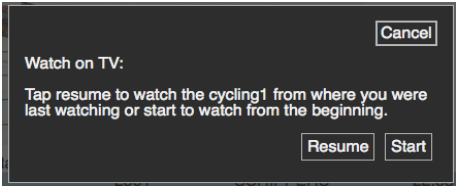
Commence playback dialog	Options	Description
	Start and Live	This option is available to users when they have selected a channel, which is currently broadcasting but they have yet to watch any of the content on either the television or this tablet. Therefore, they are able to watch from the start of the programme or to watch live, however resume is not available.
	Resume, Start and Live	As above, the channel is currently broadcasting, so both start and live options are available to users. However in this instance, there has already been playback on the television or this tablet by the user as the resume option is also available.
	Start	The channel has been made available but the broadcast has ended and neither the television nor this tablet has watched the channel at all. Therefore, the only option available is to watch the programme from the start.
	Resume and Start	As above the channel has come to the end of its broadcast, however either the television or this tablet have watched some of the programme. Therefore, both start and resume options are available to the user.

Table 3 - 1 Commence playback dialog options



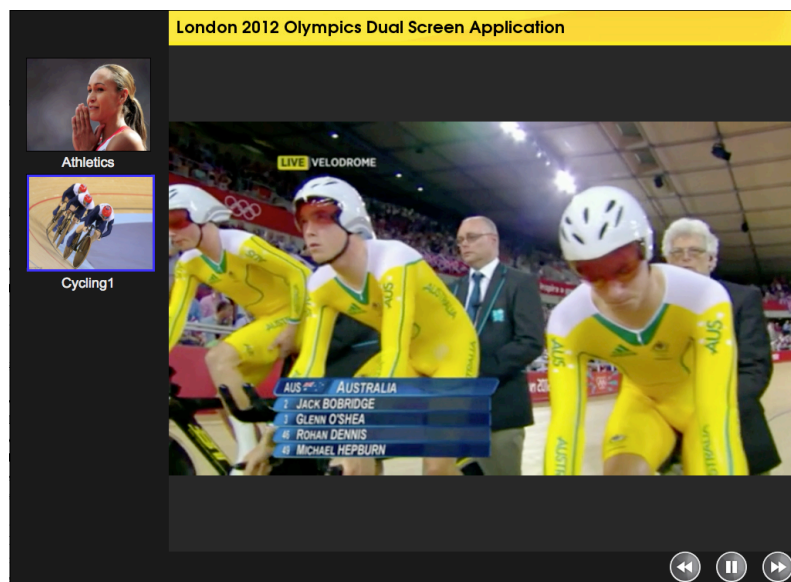


Image 3 - 9 Tablet Video Playback

Image 3-9 shows playback of the first cycling channel on the tablet. From this screenshot, it is also apparent that playback is currently happening on the TV in tandem, as the TV controls are visible and the play/pause button is showing the pause icon, indicating a press would pause the television's playback.

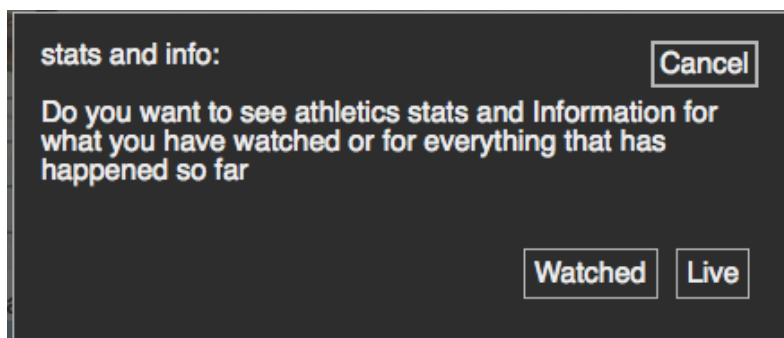


Image 3 - 10 Stats and Info dialog

Selecting the third option from the playback dialog box, stats and info, offers users two options (Image 3-10). Live statistics, offers up to the minute information on what has happened in the broadcast, relative to the content schedule, regardless of whether the programme video has been played back or not. The alternative, watched option is only available to users when they have watched the channels video content, either on this tablet or the television. Selecting watched will display only stats and info updates up until

the last played position for the channel or the current playhead if the video is currently playing back on the television.

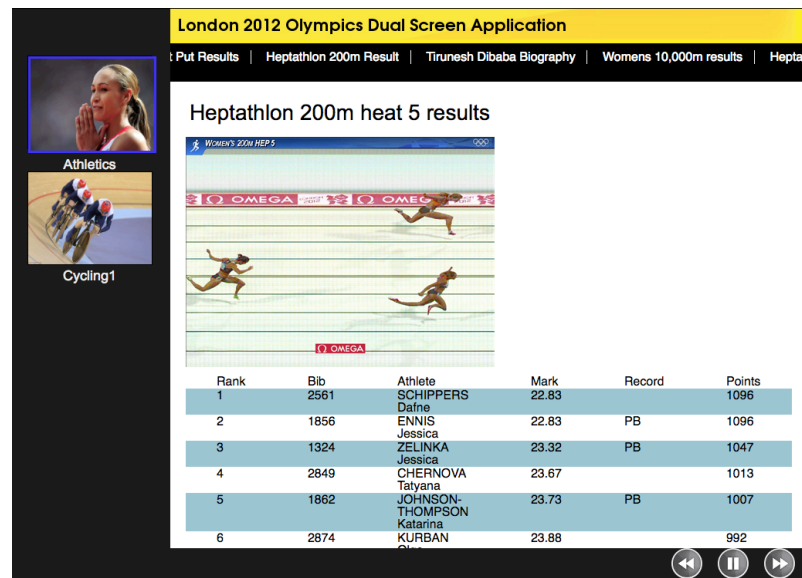


Image 3 - 11 Stats and Info displayed on the tablet

Image 3-11 shows a typical statistics update page for an athletic event, in this case the Heptathlon 200m heat 5 results, including a photo finish image. The pages available to users are displayed as a horizontal list across the top of the tablets screen. If the channel is currently being played back on the TV or if live stats had been selected from the stats and info dialog box, new pages are added to this list as the television playhead increases, revealing the results of events, and additional information about sports and athletes.

Image 3-12 is of the remote control application. Selecting one of the channel buttons immediately plays the channel from the live playhead, users do not have the option to resume or begin playback from the start of the programme. The list of channels only includes those currently broadcasting, when a programme comes to an end the channel is removed from the list. The playback buttons at the top of the remote interface. Operate in the same way as those on the tablet application, allowing users to rewind, pause, un-pause and fast-forward.



Image 3 - 12 the remote control application

### Application Content

A final important contribution of the internship to the development of the companion prototype was access to the BBC's archive of footage from the London 2012 games. The use of professionally developed broadcast footage was significant in ensuring that users had interesting entertaining and coherent programming to watch. Regardless of the event, attempting to generate professional quality footage bespoke to the user trial would be costly and prohibitively difficult.

For use in the subsequent study of the Olympic Companion Application, discussed in detail in the next chapter, a schema of content was developed for participants to watch during the trial. Five channels of content were constructed from highlights of the London Games, Athletics, Rowing, Cycling 1 and 2, and Tennis. Each of these feeds consisted of edited video highlights from the BBC's coverage and included commentary and interviews with the key athletes. For each of these channels an associated feed of statistics and information were produced which contained a series of updates on events results and additional stories about the video feed. For the purposes of the study, this content was scheduled to generate a 'golden hour', where the most exciting moments would coincide across different channels, requiring

viewers to make decision about what to watch and how best to employ their various second screen devices. For example the Men's 100 metre race was scheduled to coincide with the start of the final of the men's tennis tournament.

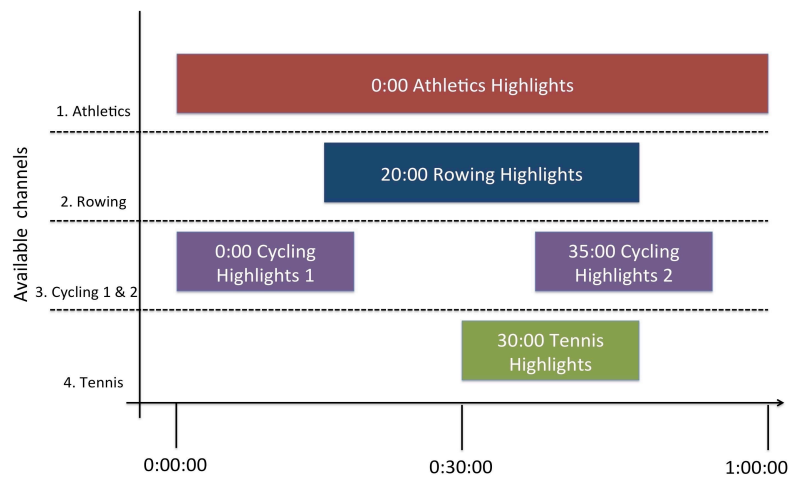


Image 3 - 13 Programming schedule for Olympic Companion Study

The study was conducted approximately one year after the games, while the study was therefore unable to encapsulate the thrill of witnessing the games live, the content schedule allowed for the production of an exciting highlights broadcast. Many of the study participants relished the opportunity to revisit the events and to see moments that they had missed during the Olympiad. The programming was also scheduled to play out during the trial so not all of the channels were available at the same time, as shown in Image 3-13. This ensured that users had to plan and schedule their viewing across the trial.

## APPLICATION USAGE SCENARIO

To further clarify the functionality and features of the Olympic Companion Application, the following figure details a scenario of the application in use. The scenario is designed to highlight the features of the application and is not representative of data collected in the study detailed in the following chapter. Additionally, the prototype is presented as a complete artefact that could be

deployed in a real world setting, without the current system limitations. The scenario assumes that the highlights are being broadcast at the time the users are engaging with the application. The scenario centres on three users of the application, Terry, Samantha and Gillian.

**Background:**

Terry, his sister Samantha and their friend Gillian are all in their mid 20s and enjoy watching big sports events together. Terry and Gillian are both keen sports players and often partner in mixed doubles tennis. While Samantha doesn't take part in sports herself she enjoys spending time watching professional sports on the television with her brother and friend.

**Scenario:**

The three get together to watch highlights of the London 2012 games in Terry's living room one evening to remind themselves of the big events and catch-up on parts of the games they had missed live. Terry has an iPad, and Samantha brings hers to use while watching. Gillian does not own an iPad but knows that Samantha and Terry will share theirs out if she wants. The first channels, the athletics and cycling channels, are due to start broadcasting at 8pm. When his guests arrive and have settled down it's around 7:55 so Terry launches the Olympic companion application on the television and on his iPad ready for the broadcast to start. They discuss between themselves which channel to watch first and decide to watch the athletics on the television, as Samantha and Terry both want to watch the heptathlon events they missed when the games were broadcast live. When the channel starts at 8pm they make sure they select the channel using the remote control and live playback begins on the television.

Gillian is less interested in seeing the Athletics and asks if it's ok to borrow Samantha's iPad to watch the cycling. Samantha hands over the iPad and Gillian launches the application. When the application has loaded she selects the cycling channel and begins watching it on the tablet from the beginning of the broadcast.

While watching the athletics, Terry has his iPad on his knee and is looking at

some of the stats and information available for the events. At the end of the 800m heat, the application displays a photo finish. This gives viewers more time to inspect the details of the image than the quick glimpse provided by the television. He calls out to Samantha “it was really close, she only just won it”. He holds out the iPad for her to inspect the photo finish image.

The Tennis channel becomes available to watch. Gillian asks Terry if he wants to watch it. He says that “he’s only interested in the Men’s final” and doesn’t mind if she wants to get into it while he and Samantha carry on watching the Athletics. Gillian starts to watch the Tennis live on the tablet. When it get’s to the men’s final, Gillian says to the others that it’s time to switch if they want to watch the Tennis. The others do want to see the tennis but the Men’s 100m final is about to start and they really don’t want to miss it. Gillian, says she also wants to watch the race, so pauses the tennis, using the tablet video controls. They enjoy the race, then Gillian selects the tennis channel again from the tablet, selects to view on the television and to resume playback from the dialog box. They pick up the tennis on the TV from the starts of the men’s final event, where she had paused a few moments ago.

## CONCLUSION

This chapter has detailed an internship with BBC Research and Development that was undertaken in the autumn of 2012 and outlined the corporation’s interest in second screen applications at the time of the internship. The principles of orchestrated media and sociality of viewing, have informed the design of the Olympic Companion Application, alongside enhancement of programming through auxiliary content and compatibility with the Universal Control API. Subsequently the design and development of the Olympic Companion Application is discussed. Chapter Four reports upon the user study that was carried out using the application. The user study was conducted in a collocated viewing environment, eliciting findings on the sharing and consumption of content by a group of interacting users with different configurations of devices.



# CHAPTER FOUR

## *Studying the Olympic Companion*

### *Application*

#### INTRODUCTION

The previous chapter discussed the design and development of the Olympic Companion, this chapter reports on a formative user study of the application. The user study sought opinions on the applications use by a collocated group of interacting participants, using an evolving number of companion devices. In this thesis the configuration of multiple companion devices is referred to as many-screen applications. The investigation sought to understand how might users coordinate their viewing and interactions when using the application across multiple second screen devices, how will this impact on users' social interaction, and what kinds of shared companion apps might be appropriate? The findings from this chapter are consolidated in Chapter Eight, along with findings from the subsequent MarathOn Multiscreen study, as a series of guidelines for the design of many-screen viewing applications.



This chapter begins by outlining the focus of the evaluation in line with the thesis questions stated in Chapter One, this is followed by the study methodology. The study findings are also detailed and the chapter concludes with initial discussions on the results.

## STUDY OBJECTIVES

The principle aim of the Olympic Companion Application's functionality and the user study design was to gather user observations and opinion on the impact of a many-screen application on collective and collocated viewing of sports programming. An observational approach was chosen for the study (and the subsequent study of the MarathOn Multiscreen application) to best address the thesis statement's focus on the social aspects of viewing. The evaluation focused predominately on the first of the three research questions outlined in Chapter one, the sharing and scheduling of content by users and the integration of additional display devices. This question is further distilled in to the three research objectives detailed in this section. In addition, the findings from this study will provide a corpus of findings on lean-back interactions, which are compared with the lean-forward interactions of the MarathOn Multiscreen study, discussed in chapters Five and Six, to aid in addressing the third thesis question.

These objectives helped to further frame the discussions at the end of the chapter and provide an "analytic foci" for the analysis, directing the development of themes (Sanderson & Fisher, 1994).

The first of these objectives was; *how might programming and supplementary media be shared between a group of collocated viewers on a collection of devices?* Television is a cooperative activity (O'Brien et al., 1999), which takes place between family and friends often in the living room, where viewers watch and experience programmes together, sharing opinions and ideas. Dual screen applications have been shown to enhance that sociality (Basapur et al., 2012) and been the focus of unpublished evaluation of industry apps, such as the 'Autumnwatch' application by BBC R&D (Jones, 2011). The Olympic Companion Application trial furthers discussion on the

social interaction of companion applications by investigating the impact of multiple second screen devices.

The second, related, objective considers *how does the many-screen approach alter the viewing experience beyond, dual screen and more traditional viewing practices?* Most prior literature has focused on the implementation of a single extra device and reported on the viewer experience, with reference to factors such as additional programme engagement with extra content and social sharing (Cesar et al., 2008), and improvement of control mechanism (Cruickshank et al., 2007). This evaluation sought users' opinion on whether the application enhanced or detracted from their expected experience of watching a single screen or engaging with a second screen application on a single additional device.

The final objective asks; *how do collocated viewers consume a schedule of television programming and associated many-screen content across an ecology of devices that changes size?* The application's design provided a feature set that allowed for programme content to be scheduled across the period of the user trial and for the number of tablets available to the participants to be increased. These characteristics afforded opportunities to discover how users responded to different configurations of tablets and managed both limited and an abundant resource between them. In addition, how they would distribute programming between those devices, as different content was made available.

The application was then studied by groups of three viewers at a time, being given increasing numbers of screens, video recording their interactions and interviewing them as a group afterwards to discuss their experiences. These observations were conducted in a laboratory setting. The study method is discussed in detail in the following section.

## STUDY METHOD

The evaluation of the Olympic Companion application was conducted in a lab based trial, which have been used by industry for evaluating companion

application (such as Vinayagathoorthy et al., 2012). This approach permitted the close observation of user activities and allowed for the evaluation to be constrained to the precise behaviours of the study aims and objectives, specifically the introduction of additional screens during the study period and the availability of content. As outlined in the approach section of Chapter One, the living lab style methodology was adopted to allow for detailed and concise data capture of user behaviour with an un-deployed prototype application, whilst maintaining an ecological awareness of television watching in the home and other social environments.

### Participants

30 participants completed the study, 16 participants were males and 14 female. Participants were selected to take part in groups of three, all users knew each other another well and watched TV together. Given the social nature of the study objectives, this condition was placed on the selected participants to minimise feelings of awkwardness between participants, who had perhaps only just met each other. Participants were recruited using university email lists and word of mouth. The email advert described the study as there was no methodological requirement to keep the details from participants. Given the requirement for all participants in a group to be friends or family, they were recruited in threes.

Three of the groups comprised of work colleagues (groups 1, 2 and 9), a further three groups of students (6,8 and 10) and 4 groups of friends (3,4,5 and 7). All participants were aged between 16 and 65 and reported experience of using smart devices, such as phones and tablets. Groups of three were selected, as three is the smallest number of participants where group behaviours are demonstrated, allowing for their interaction be more readily interpreted during data analysis, and that increasing the this number further would put undue strain on the system and networking infrastructure it was running on. Table 4 -1 summarises the relationship between group members and highlights their experience of media multitasking and smart devices.

Prior to the commencement of the study all participants signed a consent form stating they understood the nature of the study and had agreed to take part willingly. The consent form also informed user that their data would be kept securely, in accordance with data protection, their anonymity would be protected and that they could withdraw at anytime. The ethics and consent process was approved by the departmental ethics committee.

<b>Group</b>	<b>Relationships</b>	<b>Multiscreen experience</b>	<b>Smart device experience</b>
1	Colleagues	Meshing, no apps	All experienced
2	Colleagues	Meshing, no apps but red button	All experienced
3	School friends	Meshing by 2, one stacks frequently limited apps	All experienced
4	School friends	Meshing, some app	All experienced
5	School friends	Meshing, no apps	All experienced
6	2 Brothers and friend all students	Meshing, no apps	All experienced
7	Friends	Limited meshing, some stacking by one participant, no apps.	All have smartphones
8	Students, friends	Meshing	All have smartphones
9	Colleagues	Occasional meshing by 2 participants not by the other.	Smartphones, limited tablet
10	Couple and friend all students	Meshing, no apps	Smartphones, limited table

Table 4 - 1 Study groups and their pre-existing experience

Prior to the study being conducted by the main study participants two pilot sessions were run. These study groups were conducted to ensure descriptions of how to use the application and interview questions were understandable, the study procedure was effective in obtaining results pertinent to the study aims and objectives, and that the application was stable enough to be tested by a group of users over the period of the study. While there were no

identified problems with the application several changes were made to the study design, as discussed in the design subsection below.

#### Lab layout and apparatus

The study environment was setup to replicate the living laboratories used in industry, such as by BBC R&D. While the layout used for the Olympic Companion application study was temporary and more ad-hoc by necessity, it included living room style furniture and the distracting and unnatural effects of data capture were minimised where possible. A sofa, comfortable chair and coffee table were arranged around a mid-sized flat screen TV, so all participants had a good view of the television in whichever position they sat in. The coffee table was added during piloting as it meant that when additional tablets were added during the trial they could be placed neutrally in between the participants, instead of being handed to one of them, which would have guided the interaction and sharing of content. The tablet application was loaded onto recent tablet computers running either iOS 6 or Android 4.2, because of tablet availability both were used during the trial. As the tablet application was built using web technologies, it was functionally identical across the two operating systems. The server and television application were ran on a laptop computer, connected to the TV via an HDMI cable and placed underneath the set.

During the study data of user interactions and behaviours was captured using two video cameras. The first camera was placed under the television pointing out at the participants and the second mounted on a tripod behind. Two issues with this setup emerged through piloting, firstly that the sound from the television masked much of the conversation between users. Connecting an external microphone to the camera and placing it on the coffee table reduced this problem. The second issue with the camera configuration was that the camera placed behind the participants did not add any additional detail that could be identified from the front facing camera, so this feed was not used in the data analysis, however was retained for additional data redundancy during the study.

At the start of the study the group of users had access to a single tablet with a further two being added to the ecology at regular intervals, see the design section below for details. With each additional tablet made available to users during the study a pair of headphones was also provided. It was not indicated to users whether they should use the headphones or not when watching on the tablet.



Image 4 - 1 Olympic Companion study lab layout

### Design

To generate findings about the third study objective, which focuses on the effect of an ecology of companion devices that changes size, study participants had access to an increasing number of devices running the tablet application during the trial. At the start of the study period participants had access to a single tablet, the television and remote control. An extra tablet was given to the participants to use 20 minutes into the trial and then another tablet at 35 minutes.

During the pilot studies users were asked to make a free choice about what content they watched and what auxiliary content they engaged with. Pilot study group two became absorbed in the athletics on the television and were observed to be less willing to change the channel or watch on the tablet when other content was available. Therefore a few subtle changes were made

to user instruction and the content layout to ensure that users engaged with the breadth of media and devices available, and offer data reflecting the first and second study objectives. The content schema was altered so that users were forced to make a choice from the start of the study as to what to watch on the TV and the tablet. This was achieved by starting the first cycling programme at the beginning of the study period alongside the athletics, in the original content layout only the athletics channel was available at the start of the trial. The behaviour exhibited by pilot group two also raised the concern that users may decide to watch the athletics channel for the whole period of the study and not engage with any of the second screen features or make decisions about whether to watch other channels and what devices to watch them on. The risk of this behaviour was reduced by asking participants to make sure they watched multiple channels during the trial, also, in the pre-study briefing users were encouraged to state preferences about particular events and they were encouraged to make sure they watched them and decided between them how they would schedule their viewing and on which devices.

During the study users had access to a printed television schedule to help them plan their viewing, this schedule is shown in Image 3-13, in the previous chapter. During the piloting stage of the trial, users struggled to understand what time channels of content would become available, the start times of channels was relative to the start of the study and users had no reference as to when that was. This was rectified by placing a count up timer on the coffee table, started at the beginning of the trial.

### Study Procedure

At the start of the trial, the workings of the application were explained to the participants and they had the opportunity to ask questions about its functionality. While the researcher prepared the application the participants were asked to discuss, with the help of the programme schedule, how they would make use of the time they had to watch, stating preferences and organising content between devices. Participants were then asked to watch Olympic Highlights for approximately 50 minutes, The study sessions were

video taped using one camera located below the television set pointing back at the participants and another behind them looking over their shoulders to maximise coverage of their activities.

At the end of the study period participants were asked to complete a short semi-structured interview, explaining their experiences with the application. Questions centred on user opinion of the application, how they managed the content across the devices and what they believed to be the effect of adding additional tablets during the trial.

In addition to the video recordings of the applications in use, system logs were collected capturing user interactions. These system logs recorded users selecting different channels on each device, loading statistical updates and playhead interactions, such as pause and rewind. This data was subsequently analysed thematically, coding key moments of interaction, collaboration and user error, from the trial video recordings. Additionally user opinion and reflections were codified from the interview data. These nodes were subsequently ordered into higher level categories, this process is discussed in more detail in the data analysis subsection below.

### Data Analysis

The data collected during the Olympic Companion application study included both video data of participants using the devices and system logs. Whilst there are many tools available for the analysis of video data (such as NVIVO and Atlas.ti) fewer are able to integrate video data with synchronised textual information. The “Digital Replay System” (DRS) (Brundell et al., 2008) is one such system that allows for the synchronisation of system logs with multiple streams of video. However, these systems do not provide ready access to the context specific information that maybe useful while analysing many-screen data. Easily being able to determine what content is playing on which device, whether the user has paused, fast-forwarded or rewound and the current playhead makes the data analysis process far smoother.



A simple tool was built that allowed for the playback and annotation of user trial video. An extra field was added to the log records with a video timestamp meaning that the tool could highlight current, previous and upcoming log entries in a human readable form in synchronisation with the video. In addition, a display of the state of each device, generated from the log data, was output alongside the video, therefore, during the analysis process the content playing on a tablet or the television could be easily determined.

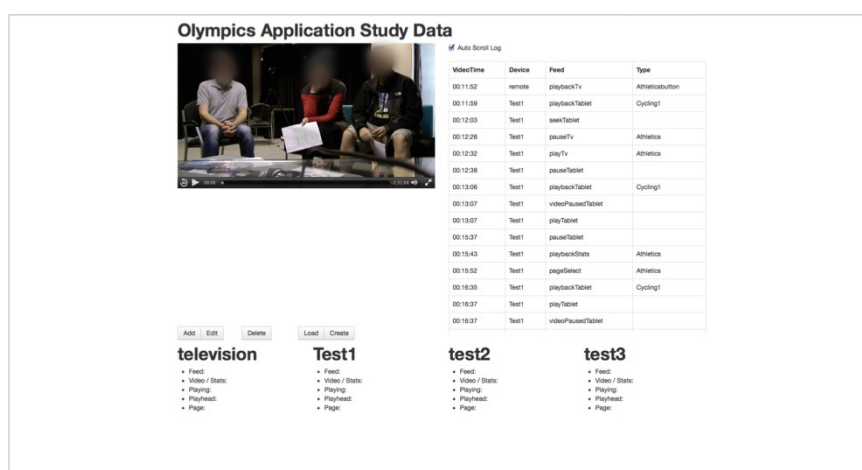


Image 4 - 2 Data playback and analysis tool

An alternative to this approach might have been to have collected more video streams during the study, possibly screen recordings of each device. However, there are a series of potential issues with this approach. First, additional cameras would be more invasive for users and reduce further the naturalism of the space. Second, that the application requires the communication and playback of resources intensive videos and additional computational load from screen captures might degrade the user experience.

The data collected during the study was coded thematically (Guest et al., 2012). Each video was systematically analysed and annotated with pertinent data points based on the study aims and objectives stated in the previous section. These initial comments were taken as basic first-level codes and grouped into organising themes. However, this resulted in 97 themes that proved to be too many to usefully aid organisation of discussions, therefore,

an additional layer of global themes was developed that grouped the organising themes into another higher layer of codes. The following results section of this chapter is organised by these top level global themes.



Image 4 - 3 Data analysis theme organisation

## FINDINGS

This section begins by summarising the codes present in the data set before outlining participants' general opinions and reflections of using the application. Following this the discussion will focus in greater detail on how users organised their local ecology of devices, how they shared devices and how they used them to control the content. Throughout the remainder of this chapter participants will be referred to anonymously by study number, for example S92 refers to study group 9 participant 2.

Table 4-2 summarises the themes present in the dataset. The themes reflect the studies analytic foci on the size and arrangement of the viewing ecology and the impact of the ecology size, the sharing of content between an interacting group of participants and the consumption of a live broadcast schedule. In addition, the codes include general user opinion on the application and user's prior experiences.

Theme	Example Subthemes	Description
General opinions	Positive attitude to application, Desire to just watch television.	Collates user opinion of the application, whether they liked and enjoyed using it.
Prior Experiences	Media stacking practice, Media meshing practice, Prior app experience.	What experiences of multiscreen television did users have before the trial
Ecology	Ecology size effect, balancing content across ecology	Codes relating to the configuration of devices and the effect of introducing additional tablets
Sociality and the arrangement of devices	Headphones and sound, role of the television	Social effects and observations of the application and how this effected the distribution of devices.
Focus and sharing	Attention switches to TV, sharing tablet content	User attention to devices and how content was shared between users
Content Control	Control confusion, application control conflict	Issues and practices around controlling the playback of content
Liveness	Understanding of live, liveness confusion	Users interpretation and issues around liveness.

Table 4 – 2 Olympic Companion Study Codes Overview

### General Opinion and Prior Experience

At the start of the trial, users were asked to talk about their experiences of watching television using second screen devices. These experiences can be categorised as either media stacking, in which case they used an Internet connected device while watching but their activities were not related to what they were watching, or media meshing where the online use reflects the content of the TV programming. Examples of stacking could include, looking up information about actors, detailed sports statistics or using a second screen application. In all groups at least 2 participants responded that they used their devices while watching to augment viewing, by playing along or looking up

further information while watching. However only 2 participants had used dedicated second screen applications. Table 4-1 summaries each group's makeup and experiences.

General responses to the application were broadly favourable from the large majority of participants, 27 of whom could see it being embedded in their television viewing practices when watching the Olympics or television viewing in general. Several responded that they could imagine using the application in a family situation where they were balancing viewing tensions between them. For example S61 describes how use of the application would allow for him to avoid the tennis highlights being watched by S63 by choosing to watch something else.

S61: "The main thing I want to have the tablet for [...] example when he [S62] was watching tennis and I want to watch another thing, coz I don't like that, I can jump to another thing."

S102 adds to this opinion by highlighting how the applications stats feature lends its self to being part of a wider social experience, she imagines using the tablet to watch the gymnastics allowing her partner, S101, the television for watching athletics. S31 and S21 also highlighted how the application's stats feature could be part of a more social experience.

S21: "The TV is inherently social. Everyone sits down together the bits of the application that go with that are being able to look up stats and negotiating what goes on the main screen."

Three of the participants however offered negative opinions towards the application. Two were reticent to engage with the multiple features of the describing a desire to just watch television without interference from the tablet, S91 was concerned about the social implications of focusing on the tablet while viewing with others.

S91: "television would be the main focus [...] If I was with other people. Say in your living room watching something. My principle concern would not to look like I was distancing myself from them by bringing that out [point to tablet.] Unless we had said 'ooh about such and such, lets look it up.'"

Broadly speaking other participants were more positive. Favourable opinions were shared on the application's ability to offer the individual user more freedom in viewing within the group, such as being able to control the television from each device and watch what they wanted on the tablet. Particularly complementary reports were given on the statistics feature, with several participants singling this out as specifically useful element of the application.

### *Opinions on Statistics feeds*

Nine groups stated that they found the statistics feature to be a welcome addition to the Olympics experience, offering more depth than the TV programme alone could provide. This reinforces findings from earlier studies, such as Basapur et al.'s (2011), where auxiliary contextual information about television programmes presented on a companion device enhanced the viewing experience.

In the Olympic Companion Application study the statistics feeds were frequently used was to discover the rules of the particular sport that was being watched on the television.

S32: "I really liked the stats and info because I didn't understand some of the cycling and I was just like read the rules and stuff and I thought that made it really useful."

In other instances users employed the statistics to fill in gaps in the audio commentary on an event and the time to take in more of the information about the event.

S102: "I liked using the stats when we weren't sure if she had won or not [Jessica Ennis, Heptathlon heat][...] that was really handy. They sort of like skipped over that."

S92: "I did like the tennis stats where you can see the report for the last set, because you normally get that really quickly on the telly version but you could actually look at it properly."

Additionally, the statistics feeds were used to fill in the 'lowlights' in the video coverage, moments where the user found the programming to not be fully engaging. Contrary to the opinions above, participant S11 criticised the

inability of the application to capture the wealth of information about events above those offered by services on the open Web.

S11: "I wasn't that fussed about having the devices there were things I wanted to know that I knew the app wouldn't know and I had to resist the urge to Google certain things."

The following sections, look beyond this initial feedback to describe participant behaviour and opinions central to the research objectives on many-screen television watching.

### Ecology, and Sociality and the Arrangement of Devices

As the trial progressed and the number of tablets available to the participants increased, the configurations employed and the sociality of users changed. 8 groups of participants responded positively to the increase in the number of tablets, stating a preference for the individual experience, the freedom of making their own selection, and a sense that they were not keeping others away from a limited resource.

S12: "At the start with the iPad I shared out info which people asked for or I found interesting, when more came in I hogged the one tablet"

S13: "In real life you would always want your own iPad you wouldn't want to be sharing it"

As well as highlighting a preference for having more tablets available, this quote is also indicative of behavioural differences between users sharing a tablet and having one each. When the participants only had access to one tablet a number of sharing practices were observed where the group decided who would use the tablet and they would be called upon by others to relay additional information about what they were watching as a group on the television (this will be discussed in greater depth in the section titled Focus and sharing.) As the number of tablets increased this sociality was observed to decrease, in instances where all three participants were using a tablet to either watch video or reading statistics, they appeared to be more isolated from each other.

One user felt that the social situation in which they were watching would reflect how available tablets would be utilised. Suggesting that limited access to tablets could spark sibling disputes as they fought over getting to use the tablet and social situations where the sharing of information between friends would be used to spark discussion and debate.

S53: "If you had the one tablet and you were siblings that you would probably fight over it [...] but if you were mates"

Additionally, when faced with a single tablet, participants were forced to more carefully consider how the devices were distributed between them and which devices the content was played on. Group members stated preferences for particular sports or events and the group tried to accommodate these while organising who was going to use the tablet and what was playing on the television.

S31: "if we start by somebody watching cycling on the tablet and two of us watch athletics on there." [...]

S33: "can I have the tablet?"

### *The role of the television*

The TV's role in the ecology for many users was as the 'big screen' the preferred focal point for viewing if it could be negotiated between users. When important events such as the men's 100m final were coming up, users would switch from watching on the tablet to the TV if they could.

S13 (watching on the tablet): "The men's 100m is coming up"

S11 (Holding the remote): "Let me know if you want it on the big screen"

This interchange was typical of discussions around the men's 100m final, often seen as the most prestigious event of summer Olympic games. It is worthy of note that all study groups watched this event on the television during the evaluation.

In another instance of negotiations for what content was viewed on the TV, both S63 and S61 were watching the Rowing channel on the tablet, while S62 was watching the tennis on the television. S61 suggested that the

configuration of devices should be reorganised so that S62 watches the tennis on the tablet and he and S63 can watch the rowing on the television. Which he considers being a fairer arrangement. S62, whose preference was to continue watching on the television, counters that he would be unable to watch the tennis on the tablet as easily as the “ball is too small” to clearly see on the tablet and that the rowing was more suited to the form factor.

### *Headphones and sound*

Participants had issues with sound overload when trying to watch video simultaneously on the television and on the tablet, where both devices were generating sound. 7 of the 10 study groups experienced this issue. Different strategies were however adopted to rectify the problem. Group 2, for example, attempted to balance sound across each device so that the tablets were loud enough to hear but not disrupt the television. However, this approach was quickly dismissed and headphones were used. Alternately, groups 9 and 10 turned the volume down on the tablets and used them just as visual video displays, relying on the on-screen graphics for contextual information. In all other instances however groups opted to use the headphones that were provided to watch the video feeds on the tablets.

S41: "It's a bit much if you've got more than one thing going on at once. But the other time using headphones made it feel a bit more asocial than otherwise."

Users wrestled with the sociality of wearing headphones while watching together in a group and the results show a distinct dichotomy. Some felt that the wearing of headphones so as not to disturb the viewing of others was the socially responsible action. Five other participants however felt that by isolating themselves from the rest of the group wearing headphones was an antisocial act and one that took them away from communal viewing on the television. 4 users were observed to try and rectify these social issues by wearing the headphones so a can covered one ear only and the other was able to hear the TV and conversations of the other viewers.





Image 4 - 4 Participants using headphones on one ear

### Focus and Sharing

The ways in which the participants shared their tablets and the content is now considered.

#### *Requesting and showing*

Two ways were observed in which statistical content available on the tablet was shared between users. The first of these was by request. When a user, who was not using a tablet at the time would ask another user to answer a question for them about what they had seen on TV or to add credence to the discussion the group were having about the events or results.

S103: "so did she win it or not."

S102: "get some stats up"

S101: [looks at the stats feed on their tablet] "she came second [...] they got the same time [...] oh you get the photo finish."

The second mode of sharing was when a user would see something of interest on the tablet and pass it on to the others. This was also used as a method of scheduling, determining what content to play next on the television or other tablets. Although the application did not have EPG features, several examples were observed where users would engage in a dialogue about what one another were watching on the tablets and the availability of channels when making decisions about what to watch next and how to balance the available content between the devices.

S42: "oh I think this might be it. Yes this is it [men's 100 metres]"

S41: "you want to get it on [the television]"

A number of ways in which this content was shared between those participants with a tablet and those without were recorded; most obvious of those was verbal communication. Other practices were however employed, which maybe of more interest to designers, as participants made use of these personal devices in a much more public way. Frequently participants would lean in to see what was on another tablet or the tablet would be held out and turned round so that other participants could see what was on it. This was observed particularly with graphical content on the tablet. Where a photo finish, an image of an athlete or video clip could not be fully conferred to the others through explanation.

S23: "It looks like a mug shot or something. [S21 leans over to see tablet]"

S22: "Is that the tennis things"

S23: "No [shows tablet to S22]"

Images 4-5 to 4-8 show users sharing content with each other and interactions with the tablets.

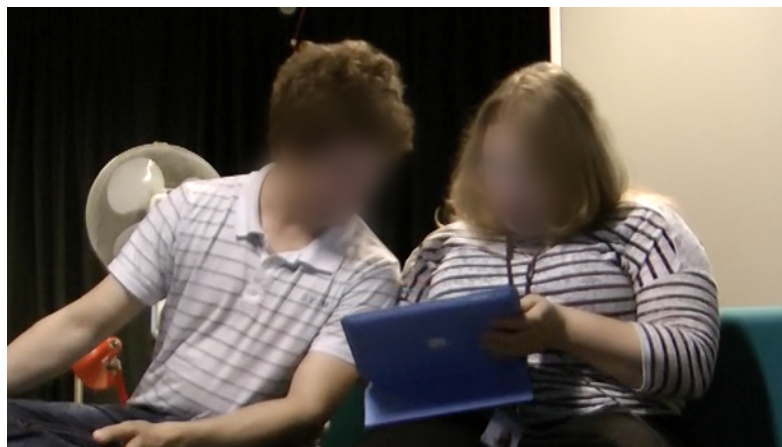


Image 4 - 5 Leaning in to see the tablet



Image 4 - 6 Holding out the tablet



Image 4 - 7 Leaning in and interacting with the tablet



Image 4 - 8 Leaning in to see the tablet

*Using the tablet to queue up content for the big screen*

Group 10 exhibited a distinctive and especially structured approach towards using tablets in relation to the television by using the tablet as a preview screen for queuing up what they wanted to see next on the television. While one channel was playing on the TV, the group would have another running on the tablet, which they would keep an eye on from the location of the coffee table. When an upcoming event of interest was spied on the tablet. It would be paused, when the event on the TV was finished the channel playing on the tablet would be resumed on the television at the same point as it had been paused on the tablet. The channel that had been playing on the TV was then resumed on the tablet and the process would repeat hopping between the two channels. When an additional tablet was made available to the group, this was used as a further preview screen.



Image 4 - 9 Using the tablet as a preview screen on the coffee table

*Watching alone*

Although sharing was common, it was not always the case as tablets allowed for an individual to be able to watch their choice of video content while the rest of the group watched another channel on the television. This functionality was used by at least 1 participant in 9 of the study groups at some point in their collective viewing.

*Content Control*

Both the remote control and each tablet offered a mechanism for controlling the television channel and the playhead in the video stream. During interview S72 referred to this as "a bombardment of controlling the same

thing in many different ways". During the study this led to users from 5 groups being unable to identify who was making changes to the state of the content on the television. For example if a user was interacting with the tablet and another made a change to the television station they would become concerned that they had inadvertently changed the TV station by mistake.

S82: "Oh what's happened there, was that me?"

S81: "Was that you. Did you do that [S83 nods]?"

S82: "Ok just making sure that wasn't me"

While mistaken actions and confusion between control mechanisms was characteristic of several groups' experiences, some used this for mischievous ends. S83 for example subjected his colleagues to multiple renditions of 'God Save The Queen' strategically rewinding so that the medal ceremony looped repeatedly. This was compounded by the realisation by the other members of the group that removing the remote control from the offending participant did not stop their behaviour as they could use the tablet in the same way. S23 and S22 referred to this as S21 "Still having the power" despite them having removed the remote from his reach. During the interview S13 talks about how he could see the applications and the multiple points of control as being the "source of fights" with friends while watching, suggesting also that the amount of simultaneous choice leads to everyone having to make compromises about what and when they watch certain events.

### ***Liveness***

The application allowed participants to pause, rewind, fast-forward and play TV channels independently on different devices. This led to users from half (5) of the groups having issues with comprehending when they were watching live and when they were watching 'replayed' (somewhere behind the live playhead) events. Part of the problem was the lack of visible representation of where they were in each video, as the application did not offer visibility of the video playhead relative to the live playhead or of overall progress through the programme. This also led to confusion as to whether the fast forward functionality was available. 7 groups were observed try to fast-forward beyond the live playhead in an attempt to skip past programming

that they were not interested in, unaware that they were already watching live.

This confusion around liveness and a lack of its visibility were especially apparent when a viewer switched the television to a channel that another was already watching on the tablet, where either of these devices was not watching at the live playhead. This could cause the especially painful problem of 'spoilers' in which one device would prematurely reveal the result of an event that was being watched on another device. For example, while watching the athletics on their tablet participant S82 rewound to get back to the start of an event. Sometime later, their colleague S81 changed the TV channel to the athletics as well, but in 'live mode'. As a result, S82 got to see the result of the event too early. Group 7 experienced similar problems where the television channel was changed while S71 was watching the same channel, leading to the exclamation "they are happening at the same time but different times".

## CHAPTER DISCUSSION

This chapter concludes with an initial discussion on the findings and their relationship to the study objectives laid out at the start of the chapter. A fuller discussion of the findings from both the Olympic Companion Application and the MarathOn Multiscreen studies is presented as design guidelines in Chapter Seven, Discussion.

The Study Aims and Objectives section established three research objectives to guide the design and analysis of the Olympic Companion Application study inline with the first thesis question; (i) *how might programming and supplementary media be shared between a group of colocated viewers on a collection of devices*, (ii) *how does the many-screen approach alter the viewing experience beyond, dual screen and more traditional viewing practices*, and (iii) *how do colocated viewers consume a schedule of television programming and associated many-screen content across an ecology of devices that changes size*. Subsequently, the design, iterative development, methods and results of the Olympic Companion application

have been reported. This section introduces preliminary discussions on the findings of the Olympic Companion application study with regard to these research objectives.

## STUDY IMPLICATIONS

### ***Study Objective 1.***

*How might programming and supplementary media be shared between a group of colocated viewers on a collection of devices?*

The Olympic Companion application study was undertaken by interacting groups of three colocated participants, all viewers knew one another ensuring that they were comfortable in each other's company and limit undue social awkwardness in expressing preferences and making choices. The addition of auxiliary content engaged users with supplementary information and media, which they shared between themselves. The sharing of statistics and information was particularly in evidence when users only had access to one or two tablets and the limited resource had to be shared between one another. The statistics features was enjoyed by many of the participants in the study, who found it to enrich their experiences and enhanced the social aspects of viewing the Olympic highlights. These findings resonate with previous work on programme enhancements through the second screen, where viewers found engagement with additional content on a companion device to enhance the experience of a programme (Basapur et al 2011).

These companion application features were shared in a number of ways, with users distributing the tablets flexibly between them and leaning in to see what others are viewing, painting a more complex picture than rigid configuration of one user one tablet.

### ***Study Objective 2.***

*How does the many-screen approach alter the viewing experience beyond, dual screen and more traditional viewing practices?*

The Olympic Companion application study generated observations of users interacting with a many-screen application that can be compared and evaluated against existing literature on television and dual screen viewing. In addition at the end of the study users were asked to reflect upon their experiences of using the application and to discuss these experiences in relation to their normal viewing practices.

Watching content on a personal device in a collocated environment seems counter intuitive and antisocial, however the study results feature examples of users engaging in this behaviour. Several participants responded that they can imagine situations where they would want to be within a social group, yet isolate themselves and to watch their chosen content alone, especially within a family group, reducing sibling rivalries and intergenerational preference for programming. The introduction of headphones, allowing users to hear the audio stream of content from the tablet without distracting others from the television audio, was problematic for many users. Prior work on the use of headphones for mobile television corroborates users' dislike for using them for watching television (Buchinger et al., 2009 and Miyauchi et al., 2008).

When using the Olympic Companion Application users had access to a multitude of ways to control content that was played on the television, through each of the tablet applications and the remote control. This led to user confusion on who was controlling the television and what actions had been performed with the television. For example, had the television been rewound and the participants were watching before the live playhead, or had the content been selected to play from the start and users were able to fast-forward through events they were not interested in. An unexpected side effect of these multitudes of control were that some participants used it as an opportunity to engage in subversive behaviour, forcing others to watch content they had not intended. The issues of control were driven by a lack of "per-user feedback" (Bier & Freeman, 1991), what interactions had been completed and by whom in the group. However as each tablet is shared between the group and at no time can be it said to belong, or be logged in to



a particular user profile, the form this feedback would need to allow for the transitory flow of tablets devices around the group.

### ***Study Objective 3.***

*How do collocated viewers consume a schedule of television programming and associated many-screen content across an ecology of devices that changes size?*

The video footage and auxiliary content used in the Olympic Companion Application many-screen study was designed so that important events coincided with one another and users were likely to make choices about how to watch these big moments. The importance of the television, as the main video display and the preferred viewing location, was highlighted in these decisions, such as the men's 100 metres final race always being watched on the TV.

The addition of further tablets during the study meant that users experienced and were observed interacting with a range of device configurations during the study. These different configurations led to a change in user sociality as the new tablets were introduced as participants watched. Users expressed a preference for having access to a tablet each, however, they both reported and were observed to talk and share content amongst themselves more when there were fewer tablets in the ecology. Terrenghi et al. (2009) summarise that an understanding of the scale of a display ecosystem can be helpful in establishing the design space. This finding mirrors this idea, suggesting that being able to tailor the ecology to specific numbers of devices may be helpful in informing the design of effective socially grounded systems.

### **Study Limitations**

In this section research limitations of the Olympic companion Application study are elicited and their potential implications discussed. A wider analysis of study limitations, for this study and the MarathOn Multiscreen study, are explored in Chapter Eight.

The process of introducing additional tablets during the study allowed for users to experience, and to be observed experiencing, multiple configurations of tablets during the study. This process supported the third study research objective into how users interacted with programming with different numbers of tablets. It could be suggested that adding these additional tablets in this way forced participants into using them, even if it did not support their interaction with or consumption of the content. This issue was ameliorated by the introduction of the coffee table into the lab layout, which meant that the tablets could be placed without directing users to engage with it. Alternatively, the effects of a reduction in sociality that were observed and attributed to the addition of supplementary tablets were because of other factors of the study design. For example, the content later in the schedule may have been less conducive to sharing and discussion amongst users. The decision to employ the supplementary tablet method was twofold, firstly that the sample population was not large enough to support a between group study design where different groups had access to different configurations of devices. Secondly, introducing tablets during the study gave users the opportunity to reflect upon how the changing number of tablets affected their interaction with different configurations.

A further limitation of the study is that the sample did not include any groups who were comprised of family members. In a couple of instances users reflected on implications they perceived for the application on family groups. These reflections have been reported and highlighted as conjecture in the results section, however future studies with the Olympic Companion Application could highlight the impact of its use with intergenerational groups, an important class of television viewers.

## CONCLUSION

This chapter has detailed the objectives, methods and findings of a collaborative user evaluation utilising the Olympic Companion Application. The evaluation was primarily designed to inform the first research question, which focuses on the sharing and scheduling of television content that takes

place across one, two or more companion devices. The study highlighted the fluid ways in which content was shared between participants and the enriching experience offered by the statistics and information displays. Conversely, the companion application can also be used as a private viewing experience within a social grouping; some participants chose to watch alone and with headphones, isolating themselves from the group. This behaviour highlighted subtleties in the sociality of viewing and users' desire to remain within the group while watching alone. These findings were further complicated by the number of companion displays made available to users, which changed the observation of sharing practices.

In the following two chapters, attention will turn to the second of the applications developed as part of this thesis. Chapter Five will detail the design and development of the MarathOn Multiscreen Application, which will further inform the development of the design guidelines presented in the discussion chapter.

# CHAPTER FIVE

## *Designing the MarathOn Multiscreen Application*

### INTRODUCTION

This chapter introduces the MarathOn Multiscreen Application. The application was developed in response to the RunSpotRun project conducted at the University of Nottingham and funded by video sharing site YouTube. The RunSpotRun project, described below, investigated crowd-sourced capture of video footage from a community marathon event held in Nottingham annually. My personal involvement in the project is described along with the corpus of user-generated video data generated by the RunSpotRun mobile application developed as part of the project. The subsequent employment of the video footage in MarathOn Multiscreen is described. The focus on user-generated video (in concert with professional footage of the marathon) will inform discussions on the second thesis question. In addition, the large video archive, its variable quality and user investment, will require users to be active participants in their viewing migrating to a lean-forward experience. These issues will be discussed in detail in the next chapter, Studying MarathOn Multiscreen. The chapter will

conclude with discussions on the development of the MarathOn Multiscreen Application and outline its functionality.

## RUNSPOTRUN PROJECT

This section discusses the RunSpotRun project that informed the design and development of the MarathOn Multiscreen Application. While the project is not part of this thesis and does not contribute towards its objectives and questions, it is included here for completeness and to help explain the design decisions of the MarathOn Multiscreen Application.

The RunSpotRun project, initially called MarathOn Live, centred on the experience of recording and reviewing user-generated footage of distance running events. The development of the project was divided into two main stages of research, the first stage investigated the nature of user-generated footage at a marathon event, using smartphone cameras. The second stage centred on the development of an online review system, for post-hoc re-watching and organising of the footage taken at the marathon.

The project was funded by a grant from the online video sharing service, YouTube. Owned and operated by Google, YouTube is the world's largest video sharing site, combining community and professional video content. The project was conducted at the Mixed Reality Lab at the University of Nottingham, with regular communication with the project sponsors.

The primary goal of the RunSpotRun application was to aid users in the production of online experiences for friends and family of runners who were unable to attend the race or tools for the production of video souvenirs by spectators and competitors.

The project was designed to address the need for coverage of events that do not have enough appeal to be viable to mainstream broadcasters but have strong community interest. Events such as fêtes, parades and local running races, attract sizeable crowds and are a rich location for photography and videography, which is increasingly enabled by smartphone cameras. These

events, specifically the marathon context that is central to the project, raises several research challenges to an online video service, what metadata to generate about the event and captured participants, understanding and enhancing the work-flow of users generating and reviewing the footage, and dealing with network congestion and delay while maintaining the user experience.

### Personal Investment in the Project

My personal involvement in the project extended between October 2012 and September 2014. There was a sustained period of engagement between July and October 2013, in preparation for the user trial at the Nottingham Robin Hood Marathon.

I became aligned with the RunSpotRun project as it offered opportunities to address the part of the thesis statement concerned with the integration of user-generated content and television watching. In addition I was able to offer insight to the project on working with a professional sports broadcaster and the experience of designing and evaluating the Olympic Companion. While the RunSpotRun project involved an industry partner, the relationship between the investigators and YouTube was more distant than that of BBC R&D and myself, the work was conducted in its entirety at the University of Nottingham. However, the project was grounded in an industry interest and offered opportunity to cooperate with the most recognised online video brand.

YouTube, and other video sites, attracts user-generated video centring on any conceivable context, event or subject. RunSpotRun project shares with the Olympic Companion Application, and my internship at BBC R&D, grounding in athletic sports, but furthered investigation with the integration of amateur captured video footage. Whilst there are alternative popular contexts that could have formed a study investigating the interaction of user-generated and multiscreen television, such as concerts, or family trips or events, the opportunity to build on a sports event was fortuitous and offered a large corpus of real world footage that would have been complex and costly to

negotiate without alignment to an existing funded project. With large televised events, such as the Olympics or premiership football, the taking of video within the stadium or venue is actively discouraged, such as the banning of tablets at Old Trafford football ground (Campbell, 2014). An event, such as a local marathon, offers opportunities for filming in public streets of a large sporting event. In addition professional stills photography and video footage is made available online after the event, which allowed for the integration of user-generated and professional content that formed one of the study research objectives, discussed in the next chapter.

I was heavily involved in several elements of the projects conception, design and evaluation. My Primary role within the group was the design and development of the study schedule for the field trial of the mobile application. The aims and objectives that underpinned the trial, discussed below, were designed to offer insights into several of the disciplinary interests of the group, be that geographical coverage or user behaviour with the mobile application. However central to my research interests, those of this thesis and the development of a multiscreen companion application, is the production of a corpus of user video and associated metadata. As part of the study design role, I was also responsible for participants recruitment and liaisons, before during and after the trial.

My responsibility for the trial design extended to consideration of the ethical implications of the application. The ethics and consent challenges raised by studying a video application in an uncontrolled and public setting are numerous and complex. These questions led to the development of a workshop paper on the specific challenges present in the RunSpotRun trial, such as the filming of identifiable children, misdemeanours and embarrassing situations of none consenting members of the public. (Anstead et al., 2014)

#### RunSpotRun Mobile Application

To address the issues of the first research stage a mobile smartphone application was developed. This application allowed spectators to video record their experiences of being at a marathon using their mobile. The

application was designed with a number of potential use cases for reviewing and re-watching the user-generated videos. While videoing spectators ‘tagged’ runners by recording their bib number as they passed. These user-generated tags, the time and duration of the video, and the geolocation where the video was shot was live uploaded to a central server during the race. This allowed for the researchers to orchestrate other spectators, directing them to areas of the course with less coverage or to encourage further tagging of specific runners. In the initial prototype implementation, video data was harvested from the phones manually after participants had returned them. However a future implementation could utilise mobile networks to upload this video live, or close to live, in addition to the metadata.

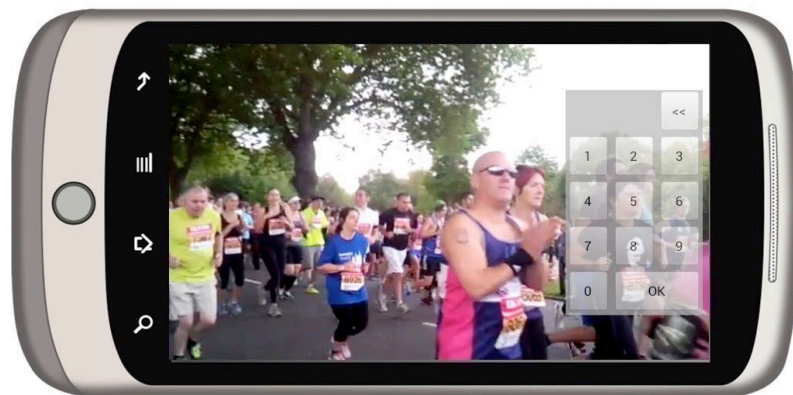


Image 5 - 1 The RunSpotRun mobile application

RunSpotRun was a student led project, open to PhD students at the University of Nottingham, who were working on research areas related to the Digital Economy theme. The project was undertaken by a group of six PhD students, all members of the Horizon Centre for Doctoral training. The group was interdisciplinary in nature, consisting of research students from the fields of, psychology, geospatial engineering, design, and computer science including HCI specialists.

### Evaluating the RunSpotRun Mobile Application

A full field trial of the Application was conducted at the Nottingham Marathon on the 29th September 2013. The event consists of a full marathon, a half marathon and a junior mini marathon. Over 8000 entrants attempted the 2013 event across these disciplines, in our trial we focused on the half



marathon, this is the most popular event with over 7000 runners. Many of the athletes we approached to take part in the trial were competing over this distance. The course of each race starts and ends at the Victoria Embankment, next to the River Trent and to the south of Nottingham city centre. While completing the course runners get to take in several of the cities major landmarks, including the University of Nottingham campus and Nottingham Castle. In the past the race has attracted over 10,000 spectators (Nottingham post, 2012).

This full-scale trial was designed to deliver formative opinions on the application in use, collected through semi-structured interviews with users. In addition, a corpus of video and metadata of user-generated footage collected during the race. These videos were used as the basis for post-hoc analysis of the quality of content produced and the quantity of race coverage.

The study was designed to meet a series of research objectives. The first objective was to investigate the effectiveness of the application in determining the coverage of the marathon course both geographically and of individual runners. Geographically the groups' interest lied in exploring where spectators locate themselves on the marathon course, how their location changed as the race unfolded and could they be influenced to move to particular filming opportunities. When considering the coverage of individual runners we were interested in investigating how much footage of a runner spectators generated. Subsequently, is it possible to increase the coverage of an individual runner through further video analysis and what errors are present in the data set. Additionally, the investigations uncovered how users at a popular marathon event made use of the mobile application. Investigating whether the application provided a complementary user experience to spectating the marathon, uncovering design opportunities for improvements and enhancements to future iterations of the app.

For the trial two types of participants were recruited. Firstly runners, who were already taking part in the marathon, were recruited to be the target of data analysis and who agreed to be the subject of requests sent to spectators

during the marathon to video specific runners. Secondly, spectators were recruited who would use the application while watching the marathon. These participants were recruited through university e-mail lists and some spectators were approached through the recommendation of participating runners. Therefore, we had a spread of spectators who were there to see specific runners we had recruited, other runners who had not been recruited as part of the trial, and those who wished to attend the marathon to see the spectacle of the event.

Spectators were briefed on what their participation would entail one or two days before the marathon. They were also loaned a smartphone with the mobile application preloaded to use at the marathon. We conducted these sessions in advance of the marathon event to ensure that the spectators located themselves along the course at a location of their choosing not the nearest part of the course to the briefing site. Therefore during the briefing we did not give spectators a prescribed location to view the marathon, however we did require them to spend at least 90 minutes along the course making use of the app. During the briefing they were shown how to use the application, given a map of the race course and informed that during the race they would be sent messages indicating runners we would like them to film or locations along the course to move to should they wish to.

During the race an orchestration room was set up from which the researchers could send messages to participants and deal with any technical issues on the ground spectators were experiencing. In the orchestration room a map of the race course was projected on a large screen that updated with spectator locations and the last tagged location of the runners we were targeting. From this map we were able to see current coverage of the course and the progress of runners we were following which had been tagged. We used this information to send short text messages to spectators, suggesting runners for them to look out for who maybe approaching their location. Also these messages were sent to increase coverage of the course by suggesting

spectators move to other vantage points where there was no coverage of the course.

After the race spectators were asked to return the loaned phones and to complete a short semi-structured interview. During the interview participants were asked about their experiences of the application and spectating the race. Questions centred on why they chose their location as vantage points for viewing the race, what motivated them to capture the runners and to tag them. Additionally, questions enquired, what were the effects of the orchestration messages and if they experienced any issues while using the application.

17 spectators and 9 runners completed the study. The spectators recorded a total of 412 videos, totalling 11 hours 29 minutes. The videos generated ranged in duration from 2 seconds to 31 minutes 10 seconds with an average length of 1 minute 48 seconds. Spectators were recorded to have travelled an average of 1.9km during the trial. 212 of these videos have been tagged as including marathon runners. Spectators tagged 3108 runners in total, of these 2616 are numbers of registered runners, therefore, at least 492 tags are erroneous.

## RUNSPOTRUN AS A MULTISCREEN CASE STUDY

Attention now returns to the main narrative of this thesis, the design and development of many-screen television experiences. This section will outline the motivations for developing the MarathOn Multiscreen Application in response to the experiences of the RunSpotRun project. Leading to the development of a multiscreen application that allows users to navigate, organise and select user-generated footage from a large corpus across a many-screen viewing ecology.

From the RunSpotRun mobile application study, a multiscreen application came into focus that explored the integration of user-generated footage into a collocated viewing ecology. Understanding how users share and organise the

footage, how is the use and distribution of the devices affected by the inclusion of crowd-sourced video and the interaction of user-generated footage with professional content. I undertook this as an individual project, whilst still maintaining a relationship with the wider project, allowing my findings to inform other aspects of the RunSpotRun goals.

### The Sociality of Spectating

The activity of live spectating a sports event is a social one, enjoyed by friends and family. Prior work has observed the possibilities for technological enhancement of watching football matches (Ludvigsen & Veerasawmy, 2010) and rallying (Esbjörnsson et al., 2006). In both examples the authors take the viewpoint that spectators are not there to just observe the match or race but to take an active role in the experience. The RunSpotRun mobile application extended these ideas to the social setting of marathon spectating (Flintham et al., 2015). Families and groups of friends go together to the marathon to watch, and to cheer on others who are taking part in the event, lending their support to those they know running and to other competitors. Therefore, the process of finding, sorting and selecting footage from the resulting collection of user-generated content as a collocated group is a salient route for further investigation. The large corpus generated by the RunSpotRun project allowed for the development of a content set for the evaluation that is interesting to users and grounded in a real event.

The MarathOn Multiscreen, and subsequent user study discussed in the remainder of this chapter and the next, investigates the review of this footage, utilising a method that reflects the sociality of spectating sports events. The study will investigate how the footage taken by both the amateur camerapersons recruited as part of the RunSpotRun evaluation and a professional video taken at the same event are consumed and shared across a many-screen viewing ecology.

The exploration of the video corpus as a singular activity, is also being investigated as part of the wider RunSpotRun project, looking at sorting and searching for content using runner number and other user-generated tags.

## APPLICATION DESCRIPTION

The MarathOn Multiscreen Application allowed users to collaboratively, watch professional and amateur video footage of the Nottingham Robin Hood Marathon across an ecology of tablet companions and a television. Offering similar functionality to the Olympic Companion Application, users can control video playback on both the companion and the television from the tablet application, and review supplementary information about the race. In addition, the application offered functionality to help users organise and navigate the user-generated amateur footage, taken at the RunSpotRun mobile application trial. This functionality included two interfaces, a map and a list, which displayed footage of a particular runner in the race, and the ability to build playlists of videos. Video playlist could be constructed of short clips of amateur footage from the race that could be reorganised and played back in succession. In the user trial playlists were used to build a series of clips of a particular runner's race.

The application was designed to run in one of two modes, this separation allowed for some functionality to be hidden from users at the start of the investigation discussed in the next chapter, revealing more functionality in the second half of the user trial. The division of the application into two mode of operation was decided upon during piloting, to ensure study findings better articulated the research objectives of the trial and that the application was not too complex to explain to users in the pre-trial briefing.

In preparation for the development of the MarathOn Multiscreen Application a reusable code base for building prototype multiscreen television applications was developed. The underlying code structure of the Olympic Companion Application was sufficient to support the desired functionality of the system but did not allow for the application to be efficiently modified as the research goals of the evaluation came into focus and the requirements evolved. Additionally, much of the core functionality of the two applications is equivalent. For example, allowing users to control the television from the tablet application, initiate video playback on both television and tablet from

start, live and resume playhead positions and delivering synchronised statistical and information pages to the tablet application. Therefore, the development of an underlying architecture could support revisions and future versions of both applications, and others built upon similar principles. The separation of the application into two modes was easily implementable, given the code and channel schema structure offered by the platform. The technical details of the architectures implementation are discussed in Appendix A, Platform Infrastructure.

The first mode of operation allowed users to watch back amateur and professional footage across the devices. In addition, this mode let users review auxiliary information about the professional content, synchronised with the broadcast. When operating in this mode the application offered similar functionality to the Olympic Companion Application. However, it was not configured to broadcast a schedule of programming, as the application is not designed to replicate the broadcast experience, therefore, all professional and amateur content is available to users from the start of the trial. This divergence from the functionality of the Olympic Companion means that the application does not represent footage as live and auxiliary content as potentially containing spoilers.

In the second mode of operation, users have access to the additional features offered by the application, allowing them to review a runner's footage and create playlists. In the user trial of the MarathOn Multiscreen Application, discussed in the next chapter, these interfaces were configured to show footage and possible footage of a particular runner, Jason. Switching between the two modes is achieved by launching the server with a different channel schema (see Appendix A) and then launching the application, the application is a single executable regardless of mode, downloading the schema from the server determines the available channels and functionality.

MararthOn Multiscreen is composed of two applications, one for the television and one for tablets, and a content server. The three components communicate through a message bus, updating each other with their state

and issuing control messages. The applications were written using HTML5 web standards, for cross device compatibility and rapid prototyping.

### Application Functionality

The sole function of the television application was to playback video content selected by users with the tablet, all interaction with the television was conducted through the tablet application. The tablet application operated in two modes, one for viewing professional and amateur content, and the other for runner tagging and building playlists of the race. In the first mode, the application had the following functionality, much of which replicates functionality of the Olympic Companion Application. How this functionality is manifest in the application and presented to users is shown in the next section, Application Walkthrough.

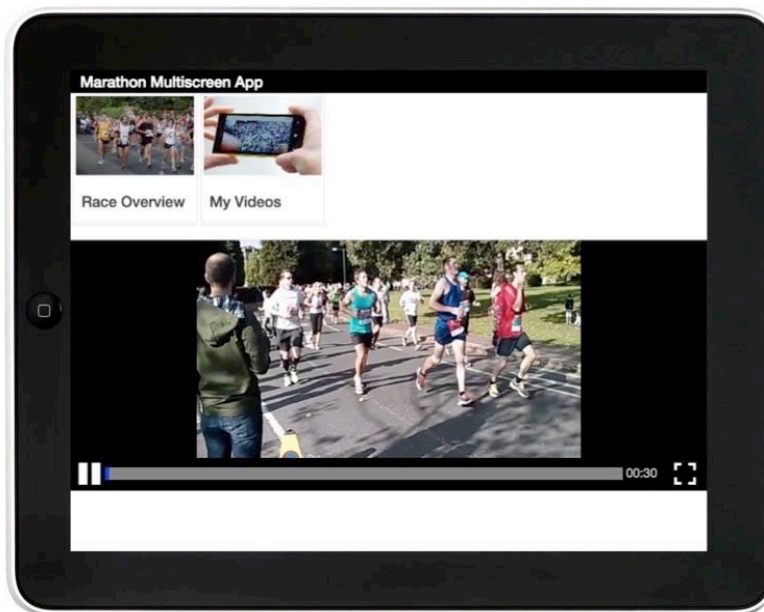


Image 5 - 2 MarathOn Multiscreen playing back video in the first mode

**Download a schedule of programming:** At the start of execution the application downloads a schedule of programming for viewing. Content is divided into channels, containing professional and amateur video footage of the marathon and auxiliary information pages.

**Playback of video content on the tablet and television:** Video content was arranged in lists, organised by professional, race overview, and amateur, my

videos. Users had the option to play content on either the tablet or the television. Subsequently, a user could select to begin playback of the footage from either the beginning of the video or to resume playback from an earlier point.

***Control the television from a second screen:*** This allowed users to select from the above videos for playback on the television. Additionally, users could pause, rewind and fast forward content playing on the television using the tablet application.

***Augment video programmes with statistics and other relevant information:*** A collection of information pages about the professional video feed were made available to users, these pages were made accessible to users in sync with video playback. These pages included information about the race history, course and results.

***Multiple second screen applications could be connected to the television:*** The system was designed to support multiple instances of the tablet application simultaneously, however, only a single television set could be connected. During the study discussed in the next chapter, users had access to two tablets throughout the trial period.

***Log user interactions:*** All user interactions with the application were sent to the server and saved to a log file, these logs aided in the analysis of the application.

When the application was operating in the second mode, the following functionality was made available to users:

***Organised Amateur Footage of runners:*** Using the metadata collected by the RunSpotRun application, MarathOn Multiscreen allowed users to review clips from the corpus of amateur video of a specific runner. Clips of video were edited to 10 seconds either side of the runner tag. The application organised these clips into two interfaces, a list of runner videos and a map interface with runner video positioned along the marathon course.



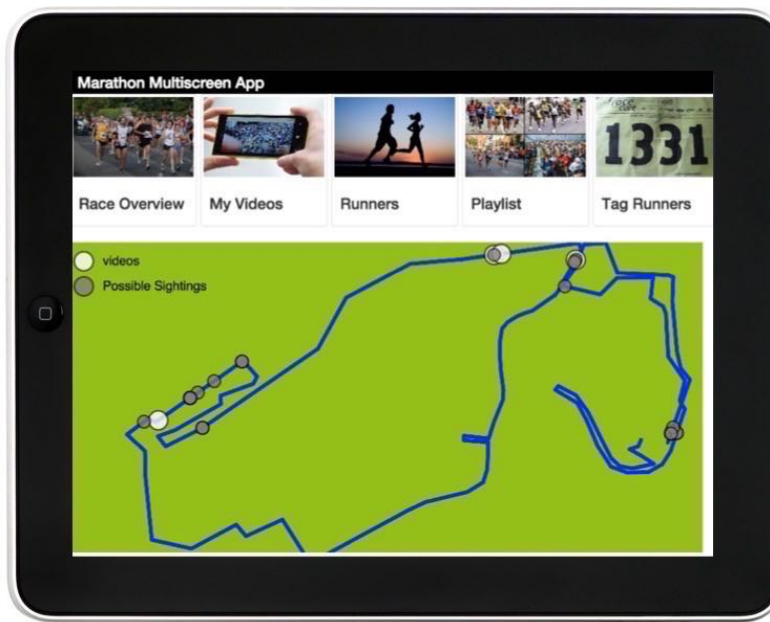


Image 5 - 3 MarathOn Multiscreen showing runner video map

In each of these interfaces, tagged videos were displayed alongside videos where the runner maybe recorded in the corpus but not been tagged. These suggested videos were presented to help users find other locations in the video where a runner of interest might be. The suggested videos were calculated based on knowledge of the runner's start and finish time and other video sightings in the metadata and extrapolating which videos they should be in based on how fast they ran between these points. For example, if there is a video that was recorded at a location between the start of the race and the known video clip of a runner, it can be calculated whether the runner ran passed during the time it was videoed and an approximate time the runner might appear in it. While this method of calculating a possible sighting of a runner is fairly crude, it did generate usable results. For the runner used in the MarathOn Multiscreen study, Jason, the algorithm detected around 20 videos he might have been in, of which 7 contained footage of his race.

**Tag Footage of a Runner:** The application allowed users to add tags to the RunSpotRun dataset. When users selected one of the suggested videos from the map or list interfaces, they had the option to view these on either the tablet or the television. Whichever they chose, a tagging button was displayed on the tablet. When a user clicked the tag button, a new tag of the

runner was added to the RunSpotRun video metadata. New tags created on one tablet would be visible to any other connected tablet in the ecology.

***Build a Playlist of Runner Footage:*** Users could build a playlist of short video clips that contain tags of runners or possible sightings. Videos on the playlist can be reorganised, removed, or played back on either the television or the tablet. A single playlist was common to all tablets in the viewing ecology, therefore additions and changes were shared and displayed across the devices.

## APPLICATION CONTENT

During the study users had access to both amateur and professional video footage, and supplementary information. The official, professionally captured and edited video was utilised, which had been uploaded to social video sites shortly after the marathon was held. This was presented alongside associated marathon facts and figures. 19 spectator videos taken during the RunSpotRun study (totalling around 13 hours of footage) which were made available for participants to view using the MarathOn Multiscreen Application. These spectator videos were labelled anonymously, stating only an approximate location of where it was taken. The only exception to this occurred if the spectator who had taken the video, had been re-recruited to take part in the study and was present.

When operated in its second mode, the application allowed runner tagging and playlist generation. The map and list view were configured to display tags and suggested videos of a single runner. Jason competed over the half marathon distance, completing the course in less than one hour thirty minutes. The decision to focus on Jason during the study was taken as there were 4 tags of him in the dataset, and there was an additional 7 videos where he featured but was not tagged. This meant that participants had a high probability of finding him in the suggested videos. Express permission from Jason had been acquired that his image could be used during the study in this way.

Despite the Multiscreen platform providing the functionality to schedule a broadcast of the footage as was implemented by the Olympic Companion Application, all the footage was made available to users at the start of the applications execution.

## APPLICATION WALKTHROUGH

Application first mode



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Image 5 - 4 The MarathOn Multiscreen Application first mode upon launch

Image 5-4 depicts operating the application in its first mode of execution, upon launching. The Horizontal list across the top of the window displays a list of channels for users to chose from. In this mode there are two channels available, Race Overview, the professional video footage and my videos the amateur video from the RunSpotRun trial.

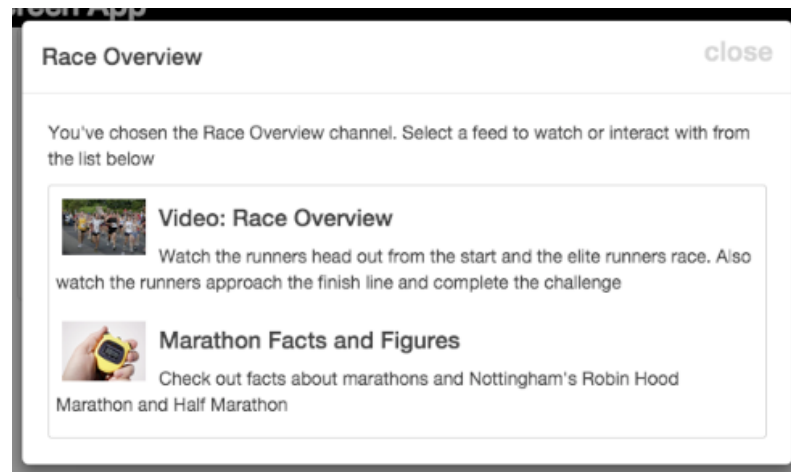


Image 5 - 5 Selecting a professional feed, video or facts and figures

Selecting either channel brings up a feed selection box, Image 5-5 shows the race overview channel, from here users can select to watch the video or look at facts and figures about the marathon.

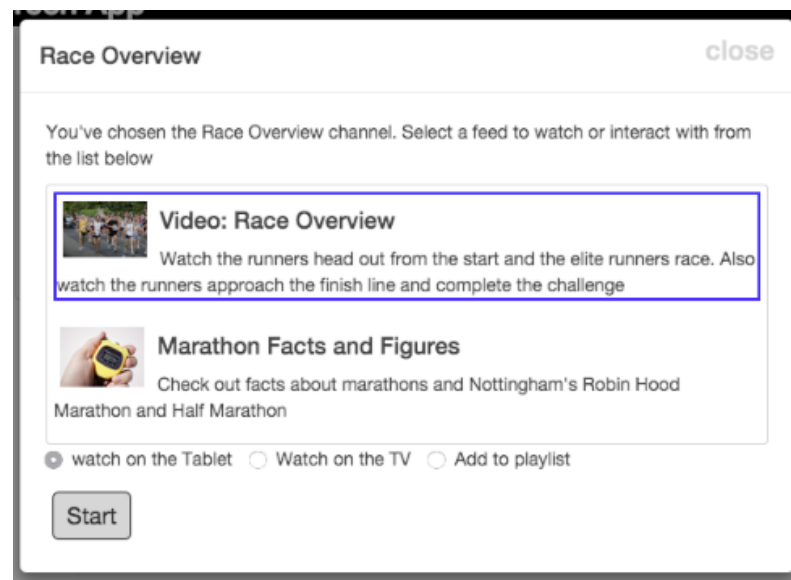


Image 5 - 6 Selecting a playback location and start playhead

Selecting the video asks users where they wish to watch the video, either on the tablet or on the television. Users are also presented with an add to playlist option, during the user study, in this mode users were asked to just ignore this option for now and that it would be explained to them later in the study. Users begin video playback by selecting start, if the video had already been played back on either the tablet or the television, a resume option would be

available which would let them pick up from the previous location in the video.

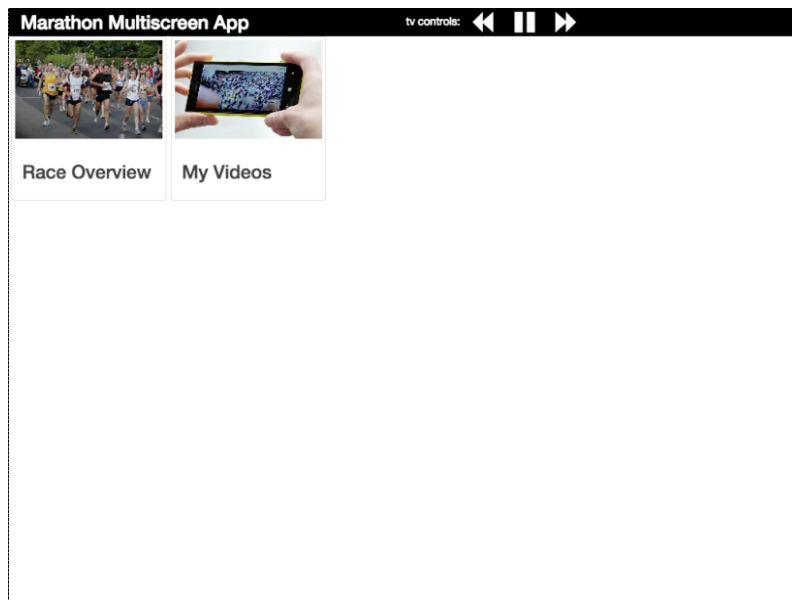


Image 5 - 7 MarathOn Multiscreen with television controls

Image 5-7 shows the main window of the application with the TV control buttons available, indicating playback on the television. From left to right these buttons allow the user to rewind, play or pause depending on the playback state of the television, (in Image 5-7 tapping that button would pause the television), and fast-forward.

Selecting the my video channel displays an equivalent dialog box to the one for the race overview channel with the same playback options, however a list of video feeds organised by spectator are available to select from. All videos are anonymised, unless a spectator from the RunSpotRun trial was taking part in which case their name would be attributed to their video feed.

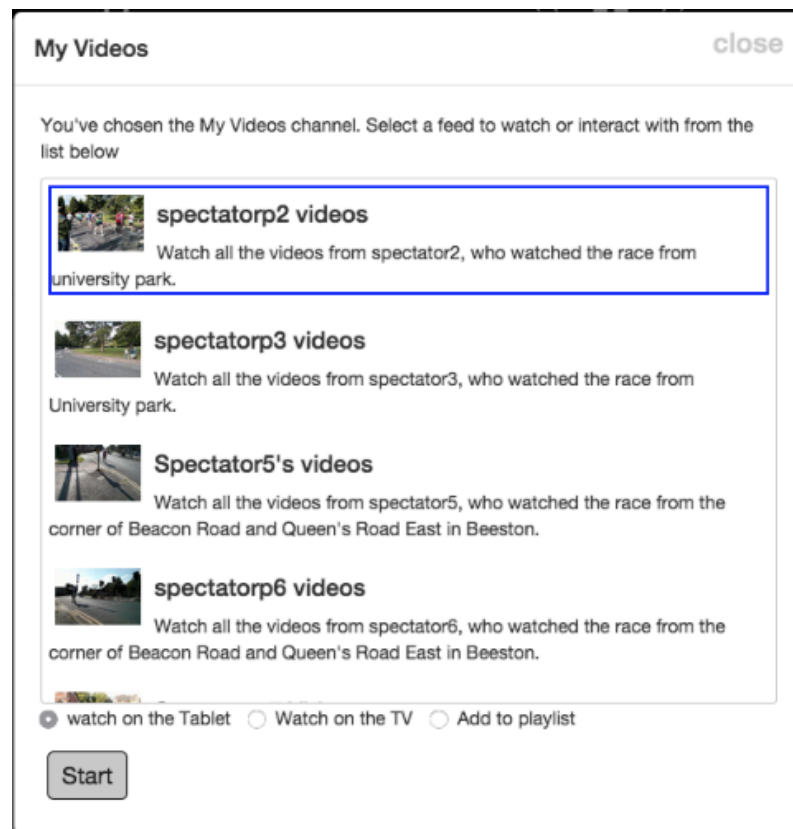


Image 5 - 8 Selecting an amateur video, device and playback location

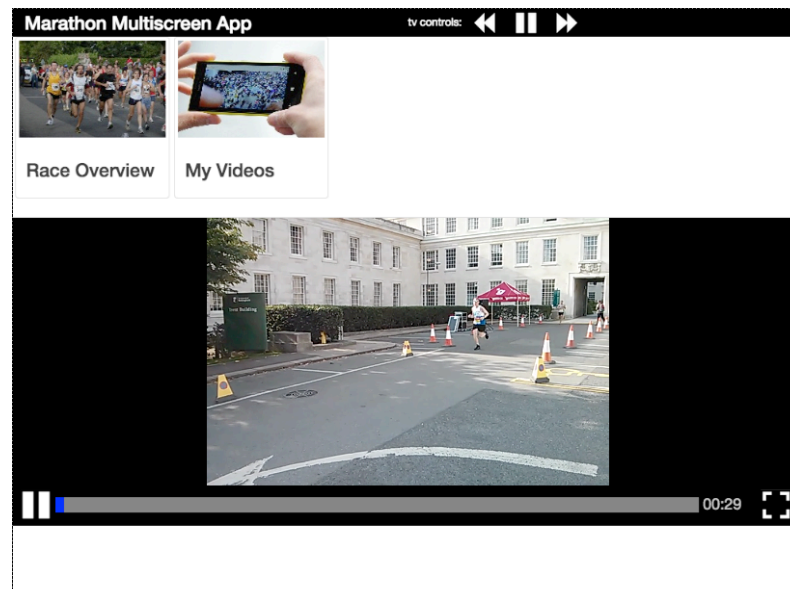


Image 5 - 9 MarathOn Multiscreen video playback on tablet

Upon selecting playback on the tablet, the video player in Image 5-9 is loaded. The player has standard video controls, play pause button, a scrubbing and progress bar, playhead counter and to the far right a fullscreen button.

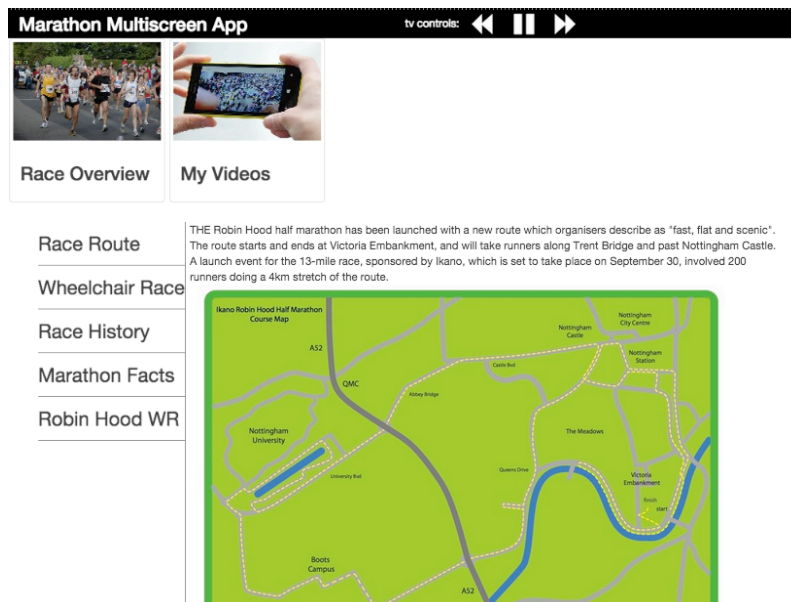


Image 5 - 10 MarathOn Multiscreen facts and figures display

Image 5-10 shows the facts and figures display for the professional video feed. Users can select updates from the left and the page content is displayed in the main part the window to the right. The list of facts and figures updates based on playback progress through the race overview video. For example while watching the professional video on the television with the facts and figures feed open, when the start of the wheelchair race is shown on the video the 'Wheelchair Race' update becomes available for the users to select.

### Application Second Mode

Image 5-11 shows how the application is presented to users in its second mode of operation. In addition to the two channels available in the first mode, users can select from three further channels, Runners, Playlist and Tag Runners. The Runners channel, contains two feeds, the map and list view for runner Jason.

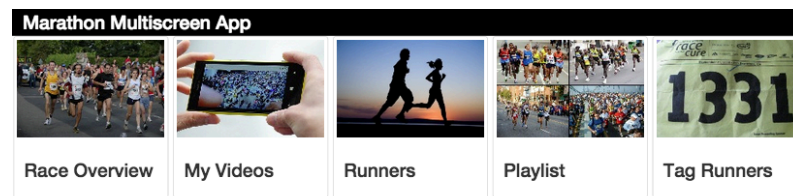


Image 5 - 11 The application upon launch in its second mode of operation

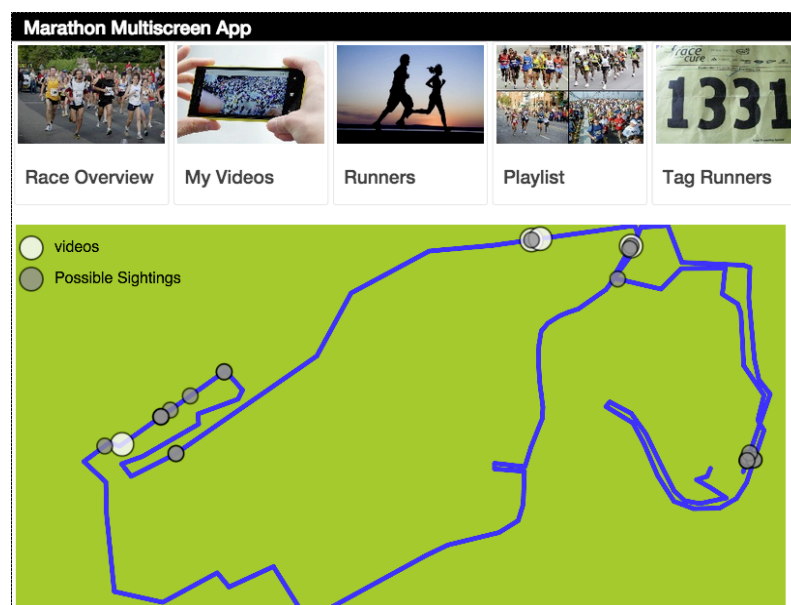


Image 5 - 12 Runner map interface

Image 5-12 shows the map interface for selecting videos of runner Jason to playback or add to the playlist. The white spots along the marathon route are videos of Jason from the RunSpotRun video corpus. The grey spots are locations where Jason might have been captured but was not tagged by spectators. Selecting either type of spot brings up a dialog box similar to the one depicted by Image 5-13. To allow for the inaccuracies of touch input and



the tight positioning of videos around the course several videos are available to select from here, the dialog also gives the option of whether to watch on the tablet, the television or whether to add the clip to the playlist.



Image 5 - 13 Runner map select video

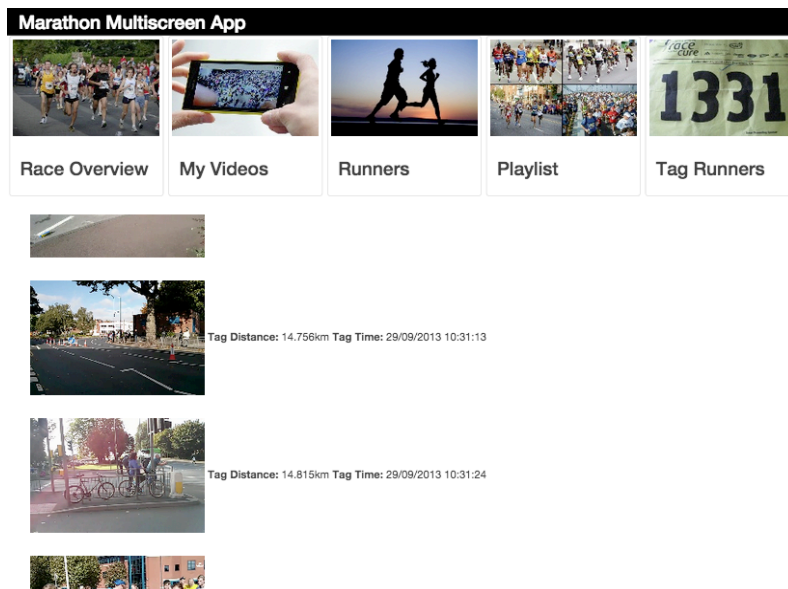


Image 5 - 14 Runner list interface

The alternative runner feed, the list view, is shown in Image 5-14. Clips are organised by distance around the course and both tagged clips and possible

sightings are shown to users. Selecting a video displays the dialog box below, this is similar to the playback dialog from the map view, however does not include the list of videos required by the tap and occlusion issues with the map.

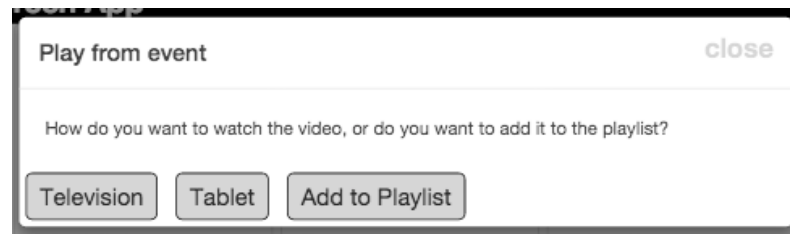


Image 5 - 15 Play event dialog box

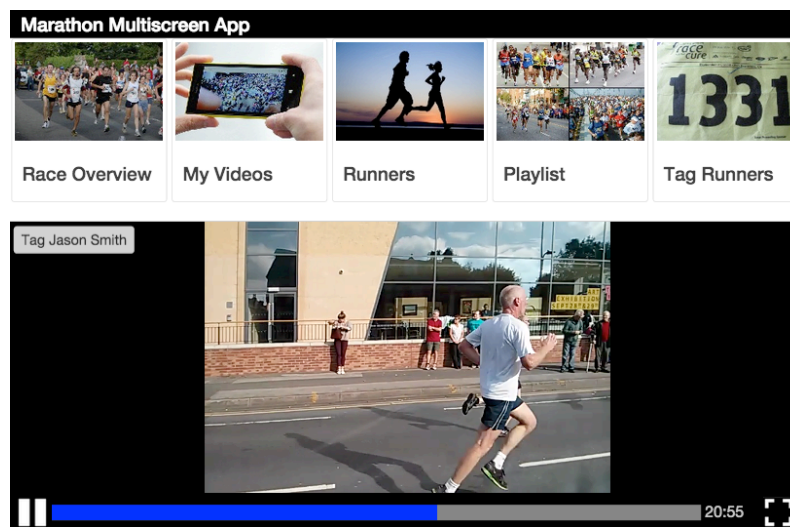


Image 5 - 16 Playback video with tag Jason button

Upon selecting to playback a video on the tablet, from either the map or the list interface, the video playback display is loaded. This is identical to the one in the first mode, with the exception of the addition of the tag Jason button. If the users see Jason within a clip, tapping here will create a new tag within the RunSpotRun metadata against the current video and playhead. Upon tapping the tag button, the message box below is displayed to confirm the success of the action.

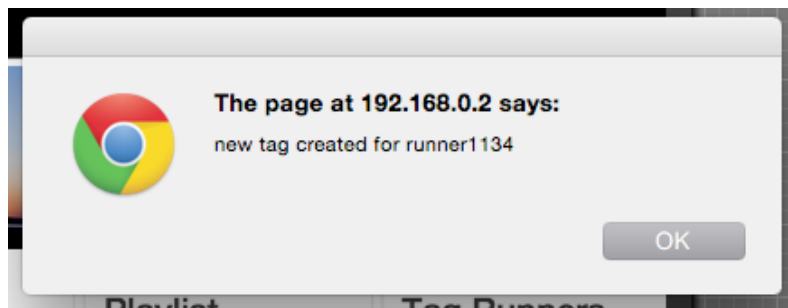


Image 5 - 17 new tag confirmation message

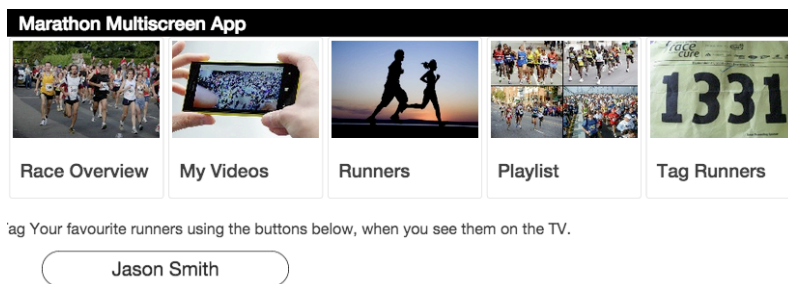


Image 5 - 18 television tagging interface

Selecting to playback a video clip on the television, instead of the tablet brings up the interface shown in Image 5-18, allowing users to tag Jason if he is seen in the video playing on the television, this works in the same way as the tag button on the video playback display, creating a tag in the RunSpotRun metadata for the current video at the current playhead. Should users be on another channel when they see Jason on the television, this display can be loaded by selecting the tag runners channel on the far right of the channel list.

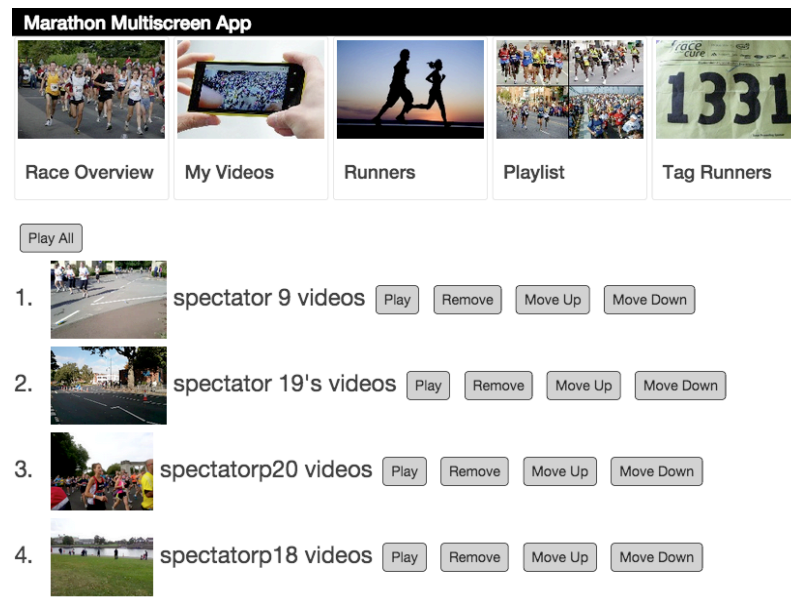


Image 5 - 19 Playlist

The final Image, 5-19, above shows the playlist channel, videos are added to the playlist from the playback dialogs from either map or list interfaces. Selecting one of the playlist options adds the video to the bottom of the playlist. From this view users can reorganise the playlist, by selecting the move up and move down options, remove from the playlist. In addition, users can playback each video individually or play back all videos in sequence from beginning to end using the play all button.

## APPLICATION USAGE SCENARIO

The following is a short scenario to further clarify how the MarathOn Multiscreen application could be used in practice. As with the scenario provided for the Olympic Companion application it is designed to highlight features of the application and position them in a naturalistic usage setting. The scenario centres around three users; Asif, Karen and Pierre, and is divided into two parts for each of the application modes.

### Background

Karen and Asif are boyfriend and girlfriend; they have been together for 6 years. Asif decided to take part in the Nottingham Robin Hood marathon as a personal challenge and to help him get fit, he competed in the half marathon

distance. Karen has supported him throughout the training process and was out on the course on the day of the marathon. She got there early to get a good spot along Castle Boulevard. In the days prior to the race she had heard about the RunSpotRun application and thought it would be a good way to record the event and would be good to show Asif her video as a memento of his achievement. She manages to capture a video of Asif running passed but in the excitement was unable to tag the footage with his number. Asif's best friend Pierre was not able to join Karen spectating the race as he was out of the country work on the day of the race.

### **Scenario**

#### **Application Mode One**

Pierre goes round to visit Asif and Karen one Saturday afternoon after he has returned from his business trip. After congratulating Asif on completing the half marathon, the three settle down in the living room to watch back footage of the marathon on the television. Both Asif and Karen have iPads which they intend to use alongside the television. Karen launches the MarathOn Multiscreen application on the TV and on her iPad, Asif also open the application on his tablet. Karen says it may take a minute to find but she has footage of Asif that she took using the RunSpotRun app. Asif Pierre suggests she maybe looks on her tablet, while they watch the professional footage on the TV. They agree this is a good idea, so Asif takes his tablet and begins playback of the professional footage. He does this by selecting the "Race Overview" channel from the channel list on the application, he then selects the video feed and to watch on the television. When the video begins playback he selects the channel again, however, this time he selects the stats and information page. The first information page loads on the tablet. Simultaneously, Karen starts playback of her video on the tablet. She selects the "my videos" channel and searches the list for her video. When she finds it she choses the "watch on tablet" option.

After a few minutes. Karen spots Asif in the video. She uses the scrub bar to rewind the video to the start of the clip and pauses the footage. She tells the

boys she has spotted Asif and then watches the professional video with them until and opportune moment to switch the footage of Asif to the television.

She then selects the “my videos” channel again and finds her feed. This time however, she selects “watch on television”. The video Karen shot plays back on the television.

### **Application Mode Two**

The group re-launch the application in it’s second mode enabling the tagging interface and playlist editor. The application is configured to show Asif’s tag list and map.

Having enjoyed seeing the clip of video of Asif taken by Karen the group want to see what other footage of Asif is in the RunSpotRun footage. Pierre begins by loading the tag map on Asif’s tablet. They see that there are three videos of Asif that have been tagged, which appear as white spots on the map. In addition, there are 6 grey spots, showing places where Asif may have been captured. They begin by watching the three videos where Asif has been tagged. Selecting them one by one Pierre taps the white spot, then selects watch on TV. In the first video Asif can just be made out from a large crowd of runners and the video is not of good quality, with a lot of camera shake. The second video is much better quality and you can clearly see Asif run passed. Karen suggests this video is added to the playlist. The other two agree so Pierre selects the white spot again and taps “add to playlist”. Karen decides to tag the footage she took of Asif, as she hadn’t managed to do it on the race day. She opens the tag list and searches the list of possible sightings of Asif. She finds her video by recognising the thumbnail image and it having the right location along the course. She plays back the video on the tablet and when she spots Asif, clicks the “Tag Asif” button in the top corner of the video feed. Her action is confirmed. She also adds this video to the playlist. Simultaneously, Pierre and Asif are using the grey, possible sighting, spots on the tag map. They are playing back the videos on the television. In two of the possible sightings they see Asif and tag him using the “tag Asif” button on the

tablet. They also add these videos to the playlist.

After going through all the sighting and possible sighting videos the group have a playlist with 4 videos of Asif. The group decide that these should be ordered chronologically and follow the course round. They watch and move the videos accordingly, using the “play”, “move up” and “move down” buttons. Upon completing the order Pierre selects “Play all” and the group watch each clip on the playlist in turn on the television.

## CONCLUSION

This chapter has detailed the design and motivations behind the development of the MarathOn Multiscreen Application. The application was inspired by involvement in the RunSpotRun project, which led to the generation of a large corpus of user-generated video footage of the Nottingham Robin Hood Marathon. The application functionality is listed in detail, illustrated with a walkthrough, scenarios and and screenshots.

The adoption of the MarathOn Multiscreen application as the second case study for this thesis maintains the focus on multiscreen television applications and the emphasis on the genre of sports television. Like the Olympic Companion study this later investigation offers insight into users’ sociality and coordination with the application. However, where the Olympic companion study included interactions and structure that replicated a live television broadcast and investigated the changing size of an ecology, the study presented in the following chapter is directed toward the integration of user generated video content and comparisons of lean forward and backward viewing.

The next chapter will report on a user study of the MarathOn Multiscreen Application, conducted using similar methodologies to the Olympic Companion Application study. The study will focus on the collaborative viewing of both professional and amateur footage, and make comparisons about the nature of lean-backward and forward viewing.

# CHAPTER SIX

## *Studying MarathOn Multiscreen*

### INTRODUCTION

Chapter Five discussed the motivations for the MarathOn Multiscreen Application, which was grounded in the experiences of working on the RunSpotRun project. In this chapter a formative user study using the application will be reported. Similar to the evaluation of the Olympic Companion Application, the study was designed to generate qualitative observations of groups of interacting participants and user opinion on the integration of user-generated video into a multiscreen viewing ecology.

The investigation sought to understand how users coordinate viewing across the content and interactions facilitated by the applications two modes of operation, transitioning between lean-forward and lean-backward viewing. In addition, the study generated findings on the changing roles of devices between viewing activities and participant's opinion on the integration of user-generated video. The findings are consolidated with those from the Olympic Companion Application, as a series of design guidelines presented in Chapter Seven.



The structure of this chapter mirrors that of Chapter Four, Studying the Olympic Companion Application. The chapter begins by outlining the focus of the evaluation in line with the thesis questions, this is followed by the study methodology. The study findings are also detailed and the chapter concludes with initial discussions on the results.

## STUDY AIMS AND OBJECTIVES

The evaluation of the MarathOn Multiscreen Application was designed with the primary aim of investigating the interaction of professional and amateur video content with an ecology of companion application, television and collocated users. A qualitative user study was conducted, designed to collate participant opinions and record observations of their interactions with the two types of content across multiple tablet devices. Predominantly this study addresses the second and third thesis questions, which focus on the integration of user-generated content and many-screen television and the difference in user behaviour between lean-backward and lean-forward tasks respectfully. In addition, this study further informs the first research question on user sharing behaviours.

The study and application discussed in this chapter were built around a collection of video recorded during the Nottingham Robin Hood Marathon and Half Marathon, which takes place each September. The corpus of amateur video footage was derived from a prior project, RunSpotRun, which developed a mobile video application, allowing spectators to record and tag runners at the marathon. With a large dataset of user-generated video, the MarathOn Multiscreen Application and study was concerned with how users interacted, across multiple display devices, when presented with both this spectator footage and a professional video uploaded to social video sites shortly after the marathon. In addition to video footage, the RunSpotRun application also generated video metadata such as user-recorded timing and location of videos. Within this study, the MarathOn Multiscreen Application makes use of this metadata to enable both organising interfaces and a runner tagging task.

Three research objectives informed the study and these objectives have shaped the discussions and conclusions around user behaviour and points-of-view. These objectives are derived from the thesis research questions providing a tighter focus for the study design and analysis of findings.

The first of these objectives is; *how do users organise and share their viewing across different viewing activities?* For example do strategies evolve that help users to consume the video across the ecology of devices, between the two types of content and across the activities they engage with during the user trial. This objective builds upon the findings from the Olympic Companion Application around the sharing of media between collocated viewers. However, shifts focus to the comparison of lean-forward and backward interactions, enabled by the two modes of the MarathOn Multiscreen Application. The inherent sociality of television watching (O'Brien et al., 1999) is enhanced by the possibilities of companion applications to enable sharing of programming across supplementary devices (Cesar et al., 2008). This sociality is reflected in the social nature of spectating sports events (Ludvigsson & Veerasawmy, 2010) that the MarathOn Multiscreen Application is designed to support through the review and selection of marathon videos.

The second objective further informs the first and third thesis question and asks; *what roles do devices take in the ecology and how do multiple devices support navigating, selecting and reviewing video as a group?* The usage and coordination of devices in a display ecology is characterised by the task that users are engaged along and their aptitude and experience (Huang, 2006). This objective considers the how the ecology is coordinated based on the tasks, both passive watching and active selecting of video content, that users were asked to engage with as part of the application evaluation. While the Olympic Companion Application evaluation was interested in configuration of users and tablets, where the availability of devices changed over the course of the study, in this instance, the number of devices remained unchanged but the nature of the tasks user engaged with altered.

The final research objective considers; *what are user opinions on the interplay of professional and amateur video content and how do users appropriate them?* During the user trial participants had access to both the amateur corpus of footage taken as part of the RunSpotRun user trial and a professionally shot video. The two video sets allowed for users to reflect upon the characteristics of amateur and professional footage. This research objective directly sets out to investigate the second thesis question. As several of the participants in this study had taken part in the RunSpotRun mobile application evaluation, this included considering the impact of footage that they had shot themselves as part of the RunSpotRun trial. Alternatively some of the participants had taken part in the marathon and had the opportunity to review footage that had been taken of them in the race.

To address these research questions, the MarathOn Multiscreen prototype was employed, allowing viewers to watch and interact with both the professional and amateur footage, as well as engage in ordering and sorting tasks with the spectator videos and associated metadata. The application design is discussed in detail in the follow section, before moving onto the study design and how both types of content were utilised.

## STUDY METHOD

The evaluation of the MarathOn Multiscreen Application was conducted in a lab based observational study. The evaluation was reflective of the Olympic Companion Application study and followed a similar methodology. The study process used in the prior study was effective in delivering useful findings on the sociality of using the multiscreen companion, with the approach utilised allowing close observation of users interacting with the application in a constrained setting. In addition, the utilisation of a similar process in this study will enable comparison of results and observations in discussions of the findings from the two studies. However, the increased complexity of the MarathOn Multiscreen Application over the Olympic Companion and the objectives around the integration of passive and active television interactions

facilitated the two part study procedure and division of the application into two running modes.

The following subsections outline in detail, the recruitment and makeup of participants, the lab layout and apparatus used in the study, study design and the data analysis process. Throughout these discussions differences with the Olympic Companion Application study will be highlighted.

### Participants

Thirty participants, in ten groups of three, completed the study. Five of the groups had an active interest and investment in the video content, each of these groups was composed from a combination of runners, spectators who had shot video using the Run Spot Run application and those who had not, and friends of Runner Jason, the target of footage searching and sorting tasks. The other five, non-invested groups, were made up of participants who did not take part in the Run Spot Run study, but had expressed an interest in watching back footage of the marathon as a community event. Groups were recruited in threes, a condition being that they knew each other well and were likely to watch TV together. As with the Olympic Companion application, this design decision ensured that users were comfortable socially with one another and limited the risk of social embarrassment from inhibiting users expressing opinion and preferences.

Participants were recruited similarly to the Olympic Companion application study, through email lists and word of mouth. Participants who had taken part in the RunSpotRun Study were recruited through the participant list from the earlier study. It is worthy of note that 4 participants completed the MarathOn Multiscreen study who had taken part in the Olympic Companion study. Their involvement was approximately a year apart. These participants did not appear to behave or interact differently as a result.

Table 6-1 summaries each group's composition. For the purposes of anonymity, every participant and group has been assigned a user code. Participants are either labelled as (a) spectator, a spectator who watched the

marathon, (b) spectator (app), a spectator who watched the marathon and used the RunSpotRun application, (c) runner, a runner in the marathon (d) friend of Jason, who was not present at the marathon but knows the runner Jason, or (e) community, a participant who is not invested in the race but lives and works in the local area and has an interest in the community event.

Group	Participant 1	Participant 2	Participant 3
I1	I11: Community	I12: Community	I13: Community
I2	I21: Spectator	I22: Spectator (app)	I23: Runner
I3	I31: Spectator (app)	I32: Spectator (app)	I33: Spectator (app)
I4	I41: Community	I42: Community	I43: Community
I5	I51: Community	I52: Community	I53: Community
I6	I61: Friend of Jason	I62: Friend of Jason	I63: Friend of Jason
I7	I71: Community	I72: Community	I73: Community
I8	I81: Community	I82: Community	I83: Community
I9	I91: Spectator	I92: Spectator (app)	I93: Spectator (app)
I10	I101: Runner	I102: Runner	I103: Runner

Table 6 – 1 Study Participants

The main study was preceded by a period of piloting that was completed by two groups. Similar to the Olympic Companion Application the intention of

these pilot sessions was to dry run the study procedure and interview questions, and to ensure the system was stable enough to be used by groups of users. It was at this point in the evaluation development that the two stage study design was adopted. In the initial design users were asked to engage in the watching of the two types of video content and to search for footage and Jason as they wished during a longer trial period. Users struggled to manage their time effectively, and it was challenging for the researcher to explain all the aspects of the application in a single briefing in a way that was clear, memorable and understandable. Another beneficial aspect of this approach was to enhance data capture around the first research question, how do users organise their viewing across different viewing activities. The details of the study procedure are described in the subsection below. Because of the structure of the multiscreen platform, allowing for channel data independent of code to be downloaded from the server at the start of a client's execution, the two application modes were enabled without any change to the MarathOn Multiscreen source code. The application changes therefore required minimal further testing and verification and did not result in significant time loss before the main study could commence.

#### Lab Layout and Apparatus

The lab layout used during the MarathOn Multiscreen study was similar to that of the Olympic Companion Application study that replicated the design of living laboratories used in the television industry. The study area was laid out with comfortable living room furniture, a sofa and chair for users to sit at as they pleased and a coffee table in front, for placing tablets and headphones. The furniture was arranged around a television set, which was connected to a laptop computer running the server and television client.

During the study user had access to two tablets running the MarathOn Multiscreen Application, these tables were running either Apple iOS 7 or Android 4.2. Unlike the previous study, research objectives here did not have an emphasis on the number tablets that users had access to, therefore the two tablets were available to participants during the whole of the study period. As it was observed in the Olympic Companion Application study that providing

each participant with a mobile device decreased the amount of discussion, need for sharing, and coordination among participants, two tablets were chosen to maximise the possible configurations of devices to users, while maintaining social interactions.

User interactions with the application and each other were captured by a front facing video camera placed under the television set. As with the Olympic Companion study, an external microphone was used to improve the quality of the sound recording and to avoid issues with sound from the television masking user comments and discussions. The second camera, placed behind users, utilised in the Olympic Companion study was not part of the apparatus used in this evaluation, as the supplementary camera angle did not yield additional data useful to the findings analysis.



Image 6 - 1 Participants using MarathOn Multiscreen

### Study Procedure and Design

At the start of the trial study participants were asked to reflect on their experiences of interacting with second screens whilst watching television. All participants were active smartphone or tablet users and stated that they engaged in media meshing (Office of Communication, 2013a), meaning they looked up facts and information about what they watched on the TV whilst watching it. For example, actor's names and sports statistics. However, only two users responded that they had used dedicated second screen television applications prior to the trial.

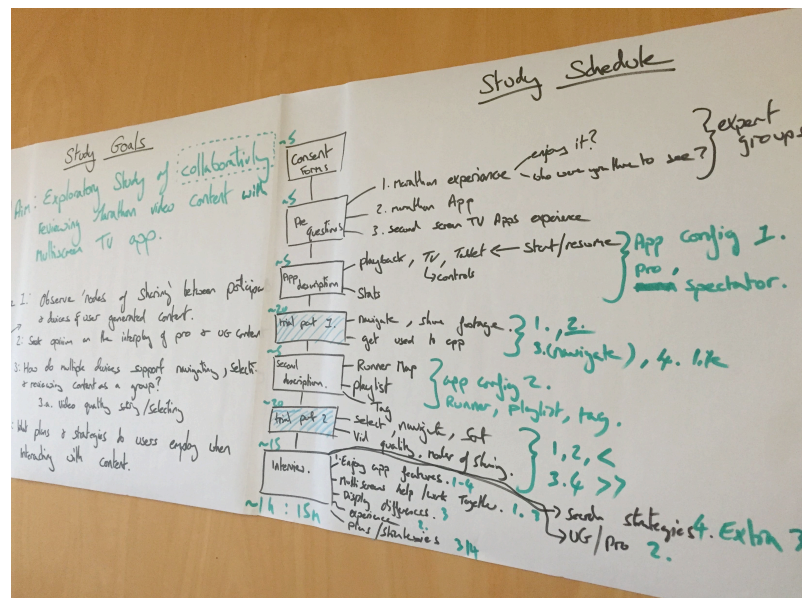


Image 6 - 2 Study Planning

The trial was divided into two sections, one for each of the application modes. The two part study structure instigated at the piloting stage allowed the aims of the study to come into sharper focus during the observations and interview. In the first half, users were asked to watch both the amateur and professional footage, between the tablets and the television as they wanted but were asked to make sure they saw some of each type of footage. Initially the applications first mode of operation was demonstrated to users, explaining how the application allowed them to watch content on both the tablet and the television, how to control the television from the tablet and how to access facts and information about the professional content. Prior to the commencement of the trial, if any participants had taken part in the RunSpotRun evaluation, their videos were unanonymised in the channel schema, if this were the case the video's location was highlighted to users in the pre briefing, so they could easily locate it during the trial.

Upon completing the briefing and any questions about the trial being answered, users had approximately 25 minutes to watch the professional and amateur footage. This was followed by a short semi-structured interview, with a target duration of around 10 minutes. During the interview participants were asked to discuss their preference for either amateur or professional



content focusing on the values that each type of content brought to the experience of watching back the marathon, how did participants share content between themselves, and how were the devices divided between them and which content was best shown on the different devices. The first half of the study was designed to elicit findings related to the second and third study objectives. Investigating users' opinions on the two types of content and how the content is organised across the viewing ecology. The design also offers a counterpoint to the second half of the study, which asked user to actively sort and select footage from the collection of amateur footage, attempting to generate findings on the first research objective.

For the second half of the user study schedule, the applications mode of operation was changed, making available the runner channel, tagging and playlist functionality. This new functionality was explained to users before they had another 25 minute period of using the application. During this second phase of interaction users were asked to look for new video footage of the runner Jason, using their choice of either the map or list interface and to tag any times they spot him in the footage where he has not been tagged previously. In addition, users were asked to build a playlist of videos of Jason during this time and to order their choices by preference. Users were told to think of the playlist as a selection of videos to be included in a video souvenir of Jason's race. Upon completion of the interactive part of the study a second 10 minute semi-structured interview was conducted. Questioning in this interview centred on how users organised themselves to help find and organise videos of Jason from the race, this along with observations of participants' strategies and configurations of devices they used helped to inform the first research objective on how users appropriated the ecology to complete the tagging task. Further questions asked for revised opinions on the application and appreciation of the content based on the experiences of second part of the trial. Finally, users were asked to reflect on the videos they had selected to be included in a souvenir, why these were chosen and rationale behind the ordering of the playlist.

## Data Analysis

The data collected from the trial included video footage of the application in use and of the semi structured interviews for each group. In addition, system logs were generated of all user interactions with the system during the user trial.

The assembled data was analysed thematically. Coding key moments of interaction, collaboration and user error from the trial video recordings. Additionally, user opinion and reflections were codified from the interview data. These nodes were subsequently ordered into high-level categories. These categories were grounded in the research questions stated in the Study Aims and Objectives section above. The following section reports on the key themes that emerged from this analysis. As was apparent in the Olympic Companion study this process yielded a very large number of themes, too many to usefully structure the findings discussion. Therefore, these organising themes were further reduced into a set of global themes.

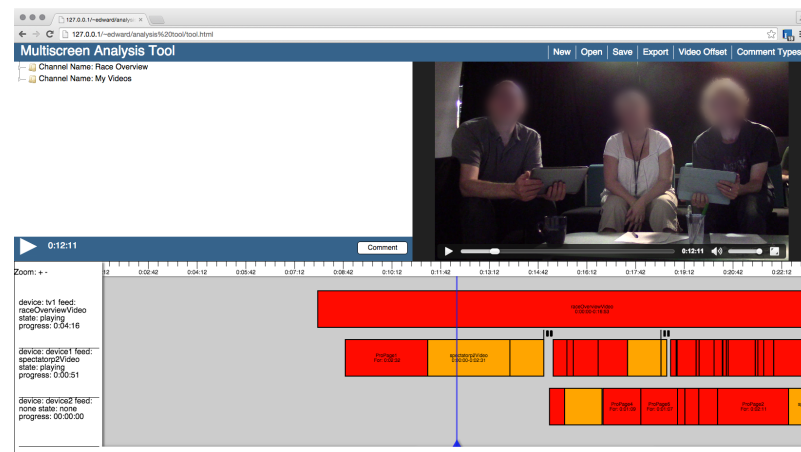


Image 6 - 3 Data Analysis Tool

Similar to the Olympic Companion study performing analysis of the video data in synchronisation with the system logs is particularly challenging, especially whilst revealing the context specific information pertinent to the multiscreen companions such as playhead position and video name. For the Olympic Companion Application, a simple analysis tool was built that synchronised the video and log data and provided a means for annotating the

data with relevant data points. A revised analysis tool was constructed for the MarathOn Multiscreen study that supported the log formatting from the multiscreen platform, making it reusable with subsequent studies built with the platform.

A significant enhancement to the tool was the ability to show the logs visually as shown by the above Image 6-3. The visualisation showed the sequence of current, prior and upcoming interactions with all the devices in synchronisation with the video playback, in addition to the current channel and playhead state, as shown on the far left of the image. A further enhancement to the application was the inclusion of comment types, allowing for initial thematic grouping to be done within the application itself. Furthermore, the tool allowed comment types to be shared between user groups and analysis codes to be exported into the CSV format for easy exporting into a spreadsheet, database or other qualitative tools for completing the analysis.

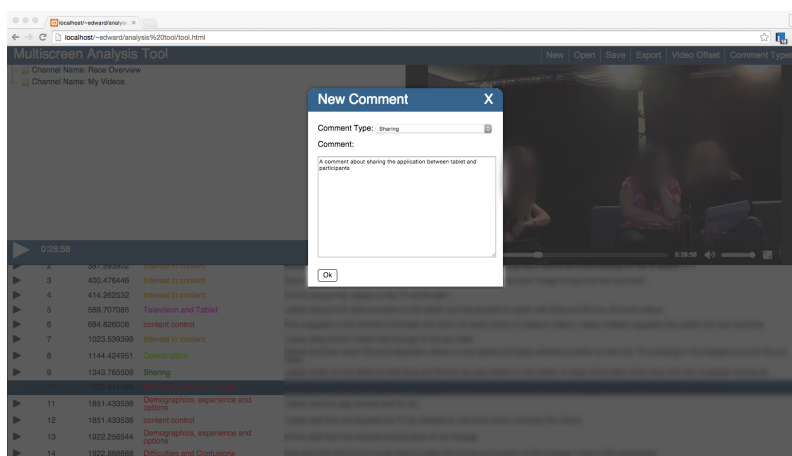


Image 6 - 4 Adding Comments in the analysis tool

## FINDINGS

This findings section begins by summarising the codes developed through the analysis and describing the differences between these codes and the ones offered by the Olympic Companion study codes. The findings begin by describing overall user opinions of the application, before looking in more detail at the strategies and sharing practices users engaged with, the control

and utilisation of the television and the tablet devices, and interaction with the amateur footage available to users during the trial.

Table 6-2 summarises the resulting themes of the analysis. Broadly these differ from the themes developed as part of the Olympic Companion Application given the analytic foci of this study that basis the analysis in viewing activities, the roles of devices and user appreciation of professional and amateur content. Codes around ecology size and its effect on sociality and liveness that were present in the Olympic Companion application study therefore do not constitute part of the analysis of this study. Instead, codes were developed that highlight the interplay of professional and amateur video, and the task of runner spotting juxtaposed by other viewing tasks. The distinction between lean forward and backward viewing is also brought to the fore by the Coordination of viewing and Inter-device relationship themes.

The Television and content control theme however, does bare resemblance to the Content Control theme from the Olympic Companion application study. The usability issues that characterises the theme from the prior study had been broadly fixed in the MarathOn Multiscreen application by a more robust design approach to user notification. Additionally, users of the MarathOn Multiscreen application had access to fewer devices resulting in less control confusion. The focus of the theme here is on pushing and pulling content between devices, which constituted a smaller part of the Olympic Companion theme, in particular these interactions involved pushing content from the tablet to the TV.

Theme	Example Subthemes	Description
General Opinions	Positive application opinion, preference for lean backward.	Collates user opinion of the application, whether they liked and enjoyed using it.
Coordination of viewing	Asserting control, strategy suggestion, pushing content to TV.	Observed behaviour and user reflections on how viewing was organised between participants and

		devices.
Television and content control	TV preference, TV Limitations, pushing content to the TV.	How content playback controlled, many of these codes focus on television control.
Inter-device relationship	Balancing TV and tablet, device coordination, strategy suggestion	How users understood and made use of the devices in performing viewing tasks, and strategies for completing the tasks.
Amateur and Professional video	Preference for pro or amateur, Amateur quality, avoiding embarrassment.	User reflections and appreciation of the two types of content available in the application.
Runner Spotting	Working together, usefulness of suggested video	Practices adopted for spotting and tagging runners.

Table 6 – 2 Summary of MarathOn Multiscreen Codes

### General Opinions

21 of the 30 participants responded positively when asked for their opinion to the application and the experience of using it to watch the professional and amateur content, and in the tagging and selecting tasks. At the conclusion of the first part of the trial all spectators were asked for their preference for either professional or amateur content as to which offered better value for watching the marathon. 19 participants stated a preference for the professional video, at the end of the first part of the trial, favouring the cleaner and more polished view of the race; this was particularly true of the groups who had not ran or spectated the marathon.

I12: "Probably the professional one was better, because it was better quality right?"

I13: "yes"

However, of the eight spectators that took part in the trial, six attributed more value to the amateur spectator footage, regarding it as a better reflection of the experience of being there. This preference was not shared by competitors, group I10, composed entirely of marathon runners, preferred the professional

video. As keen runners they liked being able to see how the professional athletes performed at the head of the pack, offering a viewpoint unavailable to them during the race.

I101: "The nice thing about the video is seeing things you can't see. Especially with the professional one, those runners are twice as fast as I am, so I'm never going to see them."

Opinions towards the amateur footage were revised significantly during the second part of the trial, with many participants, including the runners from group I10, stated a preference for interacting with the crowd-sourced videos in the tagging and selecting part of the trial:

I102: "definitely worked better for looking at the amateur footage compared to the first task, which was kind of here is a load of videos which vary from ok to rubbish and this was like here are some videos that might have something interesting in."

However, users from group I6 expressed frustration with the automated editing of clips, which included more footage than the interesting footage of Jason. They felt that this meant they would still be required to engage in a further trimming or editing task of the footage to generate a good souvenir and that this would affect the selection of videos they wanted to include.

I61: "in some of them, you get him for one or two seconds really nicely but actually there is 5 or 10 seconds either side where you have nothing, which would make a difference as to why you were choosing them."

#### Coordination of viewing

During the first part of the study, users watched the professional and amateur video content freely, without a task. As would be expected with passive television watching participants were not observed to adopt strategies that coordinated or structured their viewing across the television and tablets. The only exception to this was the initial decision of which type of content to put on the television. Seven groups discussed whether to put the professional content on the television before starting playback. The following exchange by group I3 was typical of how groups decided which content to start with.

I33: "So put on the pro stuff."

I32: "On the TV ok."

I31: "Yes, sounds like a good place to start."

The groups organised themselves in an ad-hoc manner, applying the rules of politeness and sharing to ensure that everyone got a fair chance at using the tablets when they wanted. The following quote from group I9 exemplified the feelings of many participants about managing the limited resource of the tablet amongst the group in the first part of the study.

I91: "The British polite way, I guess. I waited for those social queues that felt it was alright for me to take it. I would have just grabbed it of her otherwise. [Laughs]"

I93: "I think [I92] took the first tablet, so I waited a little bit and it seemed like you two were going to share, Then I picked up the other one"

Users did however share out information about what they were reading on the facts and figures display, accessible through the tablets. Participants shared race statistics and information with others, clearly relating it with what was being watched on the television. Eight of the study groups were observed to use the facts and figures display, with seven of these groups actively sharing around what they were reading with others in the group; enhancing and extending the experience of watching the professional video footage. For example, the following exchange by group I6 where I61 was able to inform his fellow viewers of the race route, and they were able to reflect on the surrounding areas of Nottingham.

I63: [talking about the race route to I62] "I guess it goes up through the embankment then it goes."

I61: "Here it is, it starts down here" [I61 holds out the tablet, I62 and I63 lean in to look and explore the race route]

Impromptu coordination of the TV watching was contrasted against the more strategic and organised approaches adopted by users in the tagging and ranking part of the trial. In five groups users tried to ensure that, with the tablets divided among several group participants, other members of the group did not review the same video for possible sightings of Jason. This strategy for the division of labour was guided by the interface that the group chose to use.

When using the map interface, users divided the suggested videos geographically. When using the alternative, list interface, one tablet user would select videos from the top of the list while the other would start at the bottom of the list.

I21: "So is it worth just having a quick split are you starting at the top of Jason's list"

I23: "No"

I21: "You've just selected one at Random. That's really useful."

I62: [talking about the map interface] "So shall we focus on one area the same or shall we do it with two different areas. So do some greys on the left [points to I63] and some greys on the right [point to I61]"

The methods that were employed by users to spot and tag Jason are detailed below in the Tagging Techniques section of these results.

### *Working Alone and Together*

During the tagging and ranking section of the study, groups were divided evenly between those that worked together, and those that adopted a strategy in which 2 participants worked together and 1 worked alone. The users who adopted the 'working alone' strategy were always those physically located at either the periphery of the group, rather than the participant sat in the middle. When asked about why I93 adopted this behaviour, she and I92 talked about how the app led to problems with their strategy, because they could not see what was being done by the rest of the group.

Researcher: "So, you saw what they were doing and went off and did your own thing a little bit just because it was easier?"

I93: "Maybe, I wasn't really sure what they were doing" [to I91 and I92].

I92: "It took a lot of mental energy to remember what you were doing in the app, so when two people were doing it, you're not just focusing on the app, your talking between you [...], so you forget what you were doing, as opposed to if it were a focused task for one individual,[...] it's a lot of work."





Image 6 - 5 Participants working together and alone



Image 6 - 6 Participants all working together

Group I4, evolved a strategy that involved each of them working together collaboratively across the TV and the two tablets. I43 described the strategy as having developed after the start of the task, when they had no structure to their selections; he described their lack of a strategy as leading to “complete chaos”. In their approach I41 controlled which videos were watched by the group on the TV, while I42 was primed to press the pause button should any of them spot Jason on the other tablet. I41 would then tap the tag button. Both group I4 and I9 were quite successful spotting and tagging Jason in 4 videos each, however the strategy adopted by group I9 led to two duplicated tags where as all I4s were unique. In four out of the five groups that adopted a system of two participants working together, and one working alone, duplicate tags of Jason were created. A table of duplicated tags by each user group is presented in the inter-device relationship section of these findings.

While the Jason tagging task led the groups to employ a range of strategies and practices, the ranking task showed much more consistent behaviour amongst the groups. Seven out of the ten groups worked together as a three to rank the videos of Jason into order. The factors important to the ranking exercise are reported in the Professional and Amateur video and ranking section of these findings.

### Television and Control

In the TV watching section of the trial all groups watched most or all of the professional video content on the Television. Group I6 said that this organised their viewing of the content during the first part of the study. This provided them with the “main focus” by which they could orientate their viewing on the tablet, investigate the facts and figures, and select spectator footage.

I62: “The main focus yeah, I think we all kind of thought we would could connect everything in and watch it[...]. Watch the highlights of the race, look at the map, try and figure out some sort of connection to the snippets[amateur content] as well.”

I63: “[...]I would have trouble changing it without people saying it’s what they wanted. So there is a social aspect as well.”

The television was clearly cast as the social hub of viewing, an evident focal point across all of the groups. Subsequently, users were also cautious about making sure it was appropriate to change the channel with the rest of the group and not to interfere with another participant’s viewing. As would be suspected, the size of the television played its part in ensuring that it was an important component of the viewing ecology. Additionally, users from group I4 responded positively to the enhanced methods of television control offered by the application, indicating that the features had added depth to their experience:

I43: “Larger screen, more real estate, picture quality.”

I41: “I do like the fact that it’s more interactive with your TV, It’s not just a stationary object any more, it’s the fact you can throw stuff on there, you can control it many ways, you can’t do that with a controller normally. So I think that that’s an appealing fact that you can play around with your TV with a lot more depth.”

Additional television preferences were stated after the tagging and ranking section of the trial. As discussed earlier, the characteristics of the television supported various strategies for tagging Jason as a group. Group I2 said that the television's scale enabled them to collectively confirm the identity of the runner. Participants also responded that the process of spotting him together was not only made easier but also more enjoyable.

I33: "We didn't really watch any of it on the tablet just collaboratively stared at the screen to see if we could spot him, I guess as a backup if you missed him you could maybe rely on someone else to have spotted him. [...] I think it's just more enjoyable to do it together [...] it definitely made it more interesting than working on our own."

### *Inter-device Relationship*

In some instances users struggled with the relationship between the devices. In the TV watching part of the study, the tablets operated independently, meaning that either user was able to start and control playback on the television at any time. Moreover, the viewing history was unique to each tablet, so that resuming content on the TV would pick up from the last watched place on either the TV or that tablet. Subsequent progress on the other tablet was not taken into consideration. This model was intuitive to most users, however there was some confusion in group I5, in identifying that a video could be played on the tablet, whilst still being able to use the television controls.

The inter-device relationship was altered subtly during the tagging and ranking section of the trial, where the tablets shared a common playlist of videos and tag list of runners. This functionality facilitated users working together to find videos of Jason and to order them. In four groups, duplicate videos were added to the playlist from different tablets, making the ranking task more confusing and longer, as participants tried to sort the same video more than once. Several user groups expressed frustration at not having enough information about what fellow group members were doing on the other tablet, and what was playing on the television, while they were tagging.

I52: “[The] problem is, if another user selects a video on the TV, we don't know who did that and what video”

Group	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Number of tags	3	5	1	4	5	4	9	4	6	4
Duplicate tags	0	1	0	0	0	1	0	0	2	1

Table 6 - 3 Tags and duplicated tags by groups

Table 6-2 shows the number of tags each group generated of Jason and the number of duplicated tags. Group I7 was the only group to tag runners who were not Jason, hence the inflated number of tags.

### *Content Control*

Users articulated several reasons for pushing content that was initially being watched on the tablet, to the television. Sharing amateur content was common. Users wanted to share video or facts and figures with the group because they saw interesting video or information or, in the case of the invested groups, they wanted to share out the content which they had produced

I23: “You definitely look like you were filming as I ran passed [...]”  
 I21: [Watching I23's video on the tablet] “So where do you think you were”  
 I23: “you were on University Park [...]”  
 I22: [takes the tablet to see for himself]  
 I21: “Stick it on the TV [I22 puts the video on the TV]”

In the lean-forward part of the trial users continued with this practice when searching for video footage that included Jason. Users did however find this to be a difficult process and not one the application was optimised for. Finding the video that they wanted to share with the group was hard as the interfaces did not display the videos that they had already seen, or have a mechanism for switching the tablet video to the television and vice-versa; functionality akin to that of technologies such as Airplay (Apple, 2015).

### Amateur And Professional Video

Appreciation of amateur footage involved a balance between recording quality and user interest in its content. Ranking practices, during the later part of the trial, were mostly based on the quality of the video. The amateur footage was changeable in quality and factors such as the shakiness of the shot, and the correctness of exposure and focus were paramount in decisions about how a video should be ranked. Also the quality of the footage of Jason; could he be clearly identified.

Users made considered choices before watching this content on the television. As already stated, professional content was watched by all groups on the television. This practice was observed without the group reflecting on what it may contain or their interest in it. For uninvested groups, amateur videos and videos not photographed by group members, were selected from the list without much consideration. However sometimes users would make reference to the location of the video, or that they would want to share something they had seen on the tablet with others. For the participants that had taken content, there were several reasons to watch and to share this content with the group. For example, participants from group I3 watched their videos on the tablets and did not share them with each other. During the interview they stated their reasons for watching and not sharing:

I33: "I had a quick look on the tablet but I already knew the footage I filmed was incredibly dull [laughs]".

I31: "So did I [...] was more a self-conscious thing I wanted to check was I say anything stupid."

Participant I93 took this approach even further by refusing to watch her video at all, avoiding any social embarrassment and stating that she "thought it might a bit rubbish". Participant I92 on the other hand was more ready to share and watch her videos with the group. As a prolific videographer at the marathon, she had generated over an hour of footage and was keen to see her work. Group I9 were unique in the study in that they started with a spectator video, Participants I92's, on the television rather than the professional video. I22's video, which the group believed contained footage of I23 running the

marathon, was initially watched by I21 and I22 on the tablet. When they reached the part of the video where I23 was likely to have been captured the group switched to watching the video on the television, so they could all easily see him clearly on the big screen.

During the first part of the trial users in three groups commented on a preference for the map interface for amateur footage. They felt this aided the video selection during the first part of the trial, and while this was rectified in the second part of the study, users suggested it as a way to help organise and navigate the spectator footage in the passive section of the evaluation. Conversely the group of runners I10, found the spatial organisation of the race information not to be as important to them as the timing information. They already had a good understanding of the race route, having run it, and were more interested in working out how long after the start gun the video was taken. This information would allow them to see the professional and club runners taking part, and possibly to aid in spotting themselves in the footage.

I102: "I think as a runner because it's a linear route you know you've gone passed it at some point so it's just about the time"

## CHAPTER DISCUSSION

At the start of this Chapter, three study objectives were posed in the form of research questions that framed the evaluation design and process. These questions were stated as; (i) *How do users organise and share their viewing across different viewing activities*, (ii) *what roles do devices take in the ecology and how do multiple devices support navigating, selecting and reviewing video as a group* and (iii) *what are user opinions on the interplay of professional and amateur video content and how are they appropriated by users?* In the findings section above, the results of the study are reported organised by global themes. This section includes preliminary discussion on those findings in relation to the study objectives. More detailed discussion about this studies findings are in the following chapter, along with discussions on the Olympic Companion Application.

## Study Implications

### ***Study Objective 1***

*How do users organise and share their viewing across different viewing activities?*

During the evaluation users were asked to engage with several activities whilst they were watching the professional and amateur video of the marathon. Some of these activities involved taking on tasks as a group, such as tagging additional videos of Jason or organising the playlist. Television is traditionally considered to be a 'lean-back' activity (Nielson, 2008), in which users are passively interacting with programming. During the first part of the user trial users were observed to engage in this behaviour. Conventional interaction with a desktop computer or smart device, would therefore be the reverse or 'lean-forward' activities, where users are actively engaged with a task inputting information and exerting control. The latter part of the study required users to actively engage in tagging and organisation. This part could be considered to consist of lean-forward activities that require active participation from users and different requirements for how they organise content across the viewing ecology. This approach mirrors other recent work on second screen applications that offer new opportunities for users to interact with supplementary content and social media whilst watching making for a more active experience with programming. For example, Nandakumar & Murray offers additional content to long arc story narratives through a companion app (2014) and Doughty et al's. investigation of communities generated through social media while watching (2012).

During the first, lean-backwards, half of the trial users were observed to not adopt strategies or to coordinate their viewing, as would be expected in a relaxed television watching environment. Conversely, during the second part of the study, where users were leaning forward to tag and sort videos of Jason, they had difficulty organising themselves and the content. This lack of coordination led to duplicated effort and confusion among group members and was particularly prevalent in groups where users adopted a strategy of

one participant worked alone with the tablet and the other two worked together using the television and the other tablet. Group 14's strategy of working together, across the whole ecology, allocating responsibilities to each group member was particularly successful in effectively finding videos of Jason.

### ***Study Objective 2***

*What roles do devices take in the ecology and how do multiple devices support navigating, selecting and reviewing video as a group?*

The devices role within a display ecology are shaped by the task they are setup to complete and the users who engage with them (Huang, 2006). As with the Olympic Companion Application the television played a central role in the way users shared and consumed the video content available. The big screen aspect of the television allowed users to watch together in ways not possible with the tablets alone. However, usage of the television was characterised by the mode of the application. In the first application mode professional content dominated the television, users responded that the high quality of the professionally shot and edited video belonged on the TV. In the second application mode the television took on a different significance for groups searching and sorting videos of Jason, where the scale and public aspect of the television was favoured for making collaborative decisions about tag validity and agreeing on preference for certain videos.

The tablets role in the ecology was also affected by the changing nature of the task and interactivity they entailed. In particular, users struggled to grasp the reach of their actions and to coordinate the task between themselves with the inclusion a shared playlist and runner interfaces between tablets.

### ***Study Objective 3***

*What are user opinions on the interplay of professional and amateur video content and how do users appropriate them?*

The professional video content provided users with a different viewing experience to the user-generated footage. While the amateur video was



shaky, badly framed and incorrectly exposed. The professional video was attributed with more value by users because of its production quality, tight editing and technical polish.

A group's investment in the amateur footage changed their appreciation of it. Participants who had shot footage or potentially appeared in it attributed more value to it and were more ready to accept its technical shortcomings. Users did however want to have more organisation of the footage in the lean-backward part of the study. Several user groups suggested that a map interface to organise the content would be a useful development, this was before the runner map had been made available to users in the second half of the study.

A particularly interesting finding on users' relationship with amateur content centred on participants concern over embarrassing footage they had shot. Several users from groups I3 and I9 avoided their content entirely or privately viewed it on the tablet before sharing with the rest of the group on the television. This behaviour was enabled by the ability to watch video back on the tablet as well as on the television. Embarrassment has been referenced in previous HCI literature on public displays, such as Bedwell & Caruana (2012), however less has been written about dealing with embarrassment in user-generated content.

### Study Limitations

In this section study limitations of the MarathOn Multiscreen Application are discussed. A wider exploration of the study limitations for both marathon and Olympic Companion studies can be found in the discussion chapter of this thesis.

The decision of the study into two separate halves was necessitated by the complexity of describing the application to users and to aide in the answering of the research questions posed by the study. The separation of the study schedule limited opportunities to see how users transitioned between the leaning backward television watching and the leaning forward activities of

tagging and organising footage of the runner Jason. A future study without the halved structure could investigate what factors trigger users to start on a task while watching, for example content they are not interested in or group organisation. In addition, do users schedule to complete tasks at specific times in their viewing or does a single user complete the tasks alone while others continue to passively watch using the television.

The practicalities of the study schedule partially determined the population size of 30 users across 10 groups. This along with the nature of the research questions did not lend itself to the adoption of a between studies design that altered the size of the ecology through either a disparity in the number of participants or tablets in each group. However, the scale of study was also determined by the availability of participants who had previously taken part in the RunSpotRun study. The number of group make-ups in the study was very diverse between spectators, runners, friends and other interested parties each group was unique in their composition. This meant that there was limited opportunity to make direct comparisons between different types of user or groups. Instead, the study offers ideographic findings about different classifications of marathon participants and spectators that enrich the results.

## CONCLUSION

In this chapter the research objectives, methods and findings of a collaborative user evaluation utilising the MarathOn Multiscreen Application were discussed. The study was designed with primary focus on the second and third research question posed in Chapter One of this thesis. The transition between a lean-backward viewing mode and lean-forward tasks altered utilisation of the television screen and users struggled to coordinate and comprehend their collaborative interactions across the ecology. In the first part of the trial, as with the Olympic Companion Application study, users were able to adopt ad-hoc strategies while configuring themselves and the limited resource of the two tablets. Conversely, when users engaged with the lean-forward tagging and sorting task this approach led to duplicated effort. Additionally, the study sought insight into user attitudes towards user-

generated video content. A balance guided opinion around the crowd-sourced video between quality of video footage and user investment in the footage. However, these opinions were altered by the task that users were undertaking.

The next chapter will develop on the initial discussions presented in this chapter and Chapter Four, building to a series of design guidelines to inform the design of many-screen companion applications. The next chapter will also report on a workshop exercise conducted with researchers from BBC Research and Development. The workshop evaluated the relevance of design guidelines for applicability and relevance to industry interests.

# CHAPTER SEVEN

## *Discussion & Design Guidelines*

### INTRODUCTION

The introduction of this dissertation declared the following thesis objective statement:

**The synthesis of industrially informed and verified guidelines that support the design of ‘many-screen’ television applications that allow synchronous interaction across multiple display devices. The guidelines incorporate collocated viewer requirements in respect of both watching and organising a schedule of professional sports programming and user-generated video content.**

This objective was further articulated by a series of three thesis research questions, centring on the sharing and scheduling of television content across many-screens, the interaction of lean-back and lean-forward modes of viewing, and the integration of user-generated video footage and multiple screen viewing. The previous four chapters have presented the design and

development of two studies on multiscreen television watching. The Olympic Companion Application allowed users to watch across an ecology of many-screens, scheduling and sharing highlights from the London 2012 Olympic Games. The other study, MarathOn Multiscreen gave users the opportunity to collaboratively engage with professional and amateur content taken at the Nottingham Robin Hood marathon in a multiscreen environment. Both of these studies were evaluated by users in observational studies that uncovered findings on sociality of the applications and attitudes towards watching content across multiple displays.

In this chapter a set of design guidelines are put forward that are reflective of the study findings and initial discussions presented in chapters Four and Six. These guidelines are further grounded in the literature considered in Chapter Two. The guidelines are intended to support the design of future multiscreen experiences that involve either broadcast or user-generated content. Subsequently this chapter presents and discusses a short validation exercise that was conducted using the design guidelines with user experience and engineering experts from BBC Research and Development. A group interview was conducted to ascertain the validity of the guidelines for industry and the challenges of their implementation in the broadcast environment.

A wider reflection on the research process that was carried out to answer the questions posed by the thesis are in the next, concluding chapter. Chapter Eight will pose answers to the research questions based on the design guidelines and practitioner reflections detailed here.

## APPLICATION SUMMARY

Before discussing the guidelines, the applications developed as part of this thesis are reintroduced and their differences highlighted. In the subsequent sections these differences highlight the applicability of the guidelines to the experiences offered by the two applications.

This thesis has presented the design, development and user evaluation of two many-screen television applications, The Olympic Companion Application

and MarathOn Multiscreen. These applications offered a range of complementary and contrasting functionality to aid in the exploration of the thesis research questions set out in Chapter One. The thesis questions sought to investigate, the sharing and scheduling of television content across multiple displays, the impact of user-generated video on many-screen viewing and the impact of transitioning between lean-forward and backward viewing. Table 7-1 summarises the functionality of the two applications.

Feature	Olympic Companion	MarathOn Multiscreen
Download a schedule of programming	✓	✓
Watch Programming on both tablet and television	✓	✓
Augment video with additional stats and information	✓	✓
Multiple second screen devices	✓	✓
Log user interaction	✓	✓
Broadcast a schedule of programming	✓	
Remote control Interaction	✓	
Organised Amateur video footage		✓
Tag Amateur footage		✓
Playlists		✓

Table 7 - 1 Application functionality

The Olympic Companion Application offered users the ability to review additional statistics and information about the current event as it unfolded on the television. The inclusion of this feature helped to facilitate user discussions and sharing of the highlights while they watched. However, it

was observed that this group interaction was affected by the number of tablets that were available to users at each point in the trial. The ability to watch programming on the tablet enabled parallel viewing, where users watched the highlights on the tablet while others watched on the television. Several users saw this as a desirable feature of the application, despite raising issues with the social acceptability of wearing headphones in a shared space.

The Olympic Companion Application's infrastructure broadcast a schedule of programming, this dictated the availability of highlights for users to watch and ensured decision about what content to watch and using which device. In addition to the television controls on the tablet, users had access to a remote control to interact with the content and schedule their viewing alongside these features. Users were observed to make creative use of the tablet as a preview screen, keeping track of live footage on channels other than that being watched on the television.

User appropriation of user-generated video during the MarathOn Multiscreen evaluation was observed to be dependent on the value that can be attached to the footage. In the case of the RunSpotRun footage, appropriated for use in the MarathOn Multiscreen companion, this could be because a user was the photographer of the video, or perhaps was a runner in the Robin Hood Marathon and were one of the subjects in the frame. This attribution of value diminished issues with the quality of the footage, which un-invested users struggled to get passed. User concern with the amateur video footage extended to whether they would be personally embarrassed by its quality or contents. The availability of video playback on the tablet offered users a private display, affording the ability to validate the content privately before co-viewing on the shared television. The addition of tagging and task changed user relationship with the amateur footage further, with users able to grasp more value when the footage was edited into tight clips of an individual runner.

The Olympic Companion Application was designed as a predominantly lean-back experience, without users being directed towards any task other than

passive viewing. Interactivity with the application was designed and guided by this goal. The functionality of the application allowed users to control the television with the tablet and Augment their viewing with statistics and other relevant information. The MarathOn Multiscreen Application, when operating in its second mode, offered lean-forward interactions, allowing users to review, tag and build playlists of a marathon runners race from the corpus of amateur footage. Users engaging in this lean-forward task were observed to require more organisation than those taking part in lean-backward activities. The nature of television viewing requires activities to be relaxing and entertaining, while efficiency may not be the ultimate goal here, systems should not engender frustration or be unusable.

## DESIGN GUIDELINES FOR MULTISCREEN TELEVISION APPLICATIONS

This section will lay out a series of design guidelines, developed to generalise the findings from the two studies and offer guidance to designers and developers of future companion applications that operate across many display devices. Chapter One of this dissertation outlined the thesis objective that specified the development of guidelines to inform that design of many-screen applications. These guidelines incorporate the requirements of collocated viewers watching sports programming across an ecology of devices. The following eight subsections define each guideline, along with justification, derived from the findings of the two evaluations and supporting existing literature.

The thesis objective further stipulates that the guidelines should be validated for relevance. The section that follows will report on the findings of an industry group interview, where researchers working in the broadcast industry interrogated the guidelines.

### Parallel Viewing

**Guideline 1:** *Supporting parallel viewing across devices is a desirable feature of a second screen application, especially when broadcasting a multi sport*



*tournament. However, this raises new design challenges for the delivery of audio streams.*

At first glance, the desire to concurrently view a programme on a personal device *\*and\** a television, whilst collocated with other viewers, seems an unlikely use case. However, the majority of the participants in the Olympic Companion Application evaluation responded positively to this functionality and could envisage usage scenarios where this style of interaction was a welcome addition to their television viewing experience. Several users suggested in the post trial interview that they could foresee the usefulness of the ability to watch alone while watching together as a family to ease the intergenerational tensions on what to watch, choosing their own content for the tablet, while others watch something else on the television. This finding is supported by D’heer et al.’s (2012) surveying and interviews of multiscreen equipped households. The results of their study highlighted the dual role of companion devices, not only increasing the sociality of television viewing but allowing users to privatise their television viewing within a social context. The context offered by a multi-sport tournament, such as the Olympics, offers a more complex picture of diverging between feeds on different devices as events unfold. The results of the Olympic Companion evaluation highlight several instances of users switching between watching alone on the tablet and sharing with the group on the television as the action becomes more exciting.

The privatisation of the tablet device was also in evidence in the MarathOn Multiscreen study, with the development of strategies for users to complete the tagging task and users private reviewing of their own videos taken at the marathon. User strategies are discussed in more detail in guideline 2 and private review in guideline 8. The findings from both studies add practical credence to D’heer et al.’s interview findings and develop the issue of sound delivery when watching across multiple displays.

### *Sound Implications*

As was seen in the Olympics evaluation, the watching of video on the television, simultaneously with other devices, raises issues with the delivery of audio. Previous work in the mobile television field has reported a user dislike for wearing headphones while watching the TV (Buchinger et al., 2009 and Miyauchi et al., 2008). Whilst it was not many of the study users' first choice, headphones quickly became the chosen option. 4 users in the evaluation said they found wearing of headphones to be socially isolating and diminished the communal feel of television watching. Other users attempted to try and minimise the isolating effect of wearing headphones in such a way they can still hear the conversation of other participants. In a prior study Ringel-Morris et al. (2004) describe individual audio channels for single display groupware, in one of the study conditions users were provided with headphones. The results from this study contradicted those from the Olympic Companion where users did not find the wearing of headphones to hinder their interactions with the group. This effect maybe apparent in the Olympic study because of the highly social nature of television watching. A final group of users abandoned headphones altogether and watched the video feeds on the tablet without any sound. Users who adopted this behaviour found it to be an acceptable way to watch sport programming, relying instead upon on-screen graphics.

These issues were not apparent however in the MarathOn Multiscreen study. Headphones were made available to users but were hardly utilised by any of the groups. It is likely that the lack of headphone use in the MarathOn Multiscreen study is an effect of the amateur footage that contained only ambient sound without commentary or music. The audio track of the video did not contain enough information to warrant listening or being isolated from the group with headphones.

The findings from both studies suggest there maybe a subset of video content particularly suited to use in parallel viewing situations for sports programming, where sound is not required for comprehending the action. Programming that does not require commentary, could make use of subtitles

or where on-screen graphics can substitute for the lacking audio. Not only did supporting parallel viewing afford viewers opportunities for agency in what they were watching, potentially balancing domestic tensions, it also provided a unique method of television scheduling. The consequences of multiscreen scheduling are discussed in the guideline 3.

#### Viewing across different Activities

**Guideline 2:** *Second screen and multiscreen introduces the lean-forward modality to television watching. Lean-forward tasks may require user strategies or system enforced strategies for coordinating groups to complete tasks.*

Tasks, such as the runner tagging and ranking activities that users engaged with as part of the MarathOn Multiscreen evaluation, may seem contrary to the normally relaxing and vegetative experience of television watching (Silverstone, 2004). However, multiscreen applications which interact with large quantities of crowd-sourced content, such as MarathOn Multiscreen, require users to act as curators to generate personal narrative experiences. Extant literature refers to television as being a ‘lean-back’ activity (Nielson, 2008), in which viewers are passive actors and contrasts them with ‘lean-forward’ activities, where users are actively interacting with the content, such as the familiar desktop and mobile paradigms. Vinyagamoorthy et al. (2012) poses the question that as some content displayed on the television becomes increasing interactive does the traditional view of television as a lean-backward activity needs to be revised. Recent work in second screen viewing applications has also explored the limits of television watching as a passive viewing experience, introducing new opportunities to interact with relevant additional content through secondary devices (Nandakumar & Murray, 2014) or social media updates (Doughty et al., 2012). The two phases of the MarathOn Multiscreen user trial can be mapped to these leaning modalities. The first part of the trial, where users watch the professional and amateur content, is a ‘lean-back’ activity, whilst the tagging and ranking tasks is ‘lean-forward’. Similarly the Olympic Companion Application offers users the same

levels of interaction as the first mode of the MarathOn Multiscreen Application that is considered by the same analysis to be lean-back.

During the first part of the MarathOn Multiscreen trial, where participants leaned back watching and selecting content curated for them, users were observed not employing strategies or coordinating their viewing, as would be expected in traditional passive television watching and was broadly observed during the Olympic Companion study. Content selection and control was ad-hoc and governed by users' polite willingness to share. This approach spread effectively to the sharing of facts and figures and distribution of devices. During the ranking activity, a lean-forward task, users tended to orientate together and worked collaboratively with the single playlist. Groups had few difficulties using this interface to sort the videos. However, during the tagging part of the trial, where participants were asked to search for additional footage of the marathon runner Jason, they struggled to coordinate and organise themselves. This resulted in user frustration or unnecessary duplicating of effort across the group. In 4 of the study groups duplicated tags were generated and in part that could be attributed to the strategies users evolved, such as the two and one strategy used by several groups. Group I4's strategy of working together, dividing the tasks of selecting video and tagging between the tablets, was more successful than groups who tried to divide the content between each other.

Groupware literature highlights the importance of visibility of other users' interactions for good usability of collaborative applications (Gutwin & Greenberg, 1999). MarathOn Multiscreen's usability and effectiveness as a collaborative curation tool was affected by this lack of visibility for many of the participants. However, similar to the issues of user awareness of their control actions, in the next guideline, the devices in the ecology are not designated to specific users, they are shared out amongst the group. A potential design opportunity exists here, reporting could not necessarily focus on what a user is attending to but what work has been completed and what might be an effective next task for users to undertake. In the case of

MarathOn Multiscreen this information would include what videos have been watched and tagged, and which videos could next be scoured for sightings of Jason. An alternative design policy could enforce similar behaviour to that of group 14s. For tasks, such as the tagging task, the design of the application might force strategies upon users that only allow for a single device to engage in parts of the activity. For example one tablet may select the videos to watch on the television while another is able to tag.

### Scheduling, Queuing and sharing

**Guideline 3:** *The scheduling and queuing of content playback between devices can be enabled by a range of novel mechanisms, such as resume playback, jump to event and playlists. The scale of the ecology affects sharing of content.*

A number of prior studies in HCI have investigated the use and extension of Electronic programme guides or EPGs. Some of these studies, for example Iatrino & Modeo (2007), integrate socially networking features into the EPG. Other prior examples break away from the traditional channel grid approach to programme layout and instead offer users a more intuitive layout of genre, mood or connections with other liked programmes (Harrison et al., 2008 and Abrue et al., 2014). Cruickshank et al. (2007) place these features on to a companion device to aide interaction with programme listings. Conversely, neither the Olympic Companion or the MarathOn Multiscreen Application offered EPG features to users, instead users engaged with content on the tablet, through both the video and statistical feeds, utilising the range of control mechanisms on the tablet and remote applications to ensure that the most exciting content was shared on the television for all to watch and enjoy.

Complex viewing behaviours, most notably that of queuing, were enabled by the Olympic Companion Application's 'resume' feature, allowing the user to resume playback from the tablet on the TV, and from the TV on the tablet. This feature was particularly important in allowing users the freedom to schedule their viewing across the feeds, ensuring they saw as many key events as possible. However, users suggested the option to play content on

the TV or the tablet from the start of an event, offering a potentially more elegant solution. In light of this, it is recommended in building a resume playback function between devices, or a mechanism by which viewers could skip to key moments of the action. Users of the Olympic Companion Application, “micro scheduled”<sup>1</sup> their viewing, switching between short pieces of the content between the tablets and television, this fine grained control observed is distinctly different to scheduling between complete programmes that is undertaken using an EPG. The MarathOn Multiscreen Application offered both these functionalities to users and the creative uses of the resume feature seen in the Olympic Companion Application were not evident in the latter study. The nature of the amateur content provided by the MarathOn Multiscreen Application did not follow the traditional editorial flow of the Olympic highlights offered by the other study. Users employed the resume feature when they were directed to exciting moments in the video by the build-up imagery and commentary to the next big event, offering them opportunity to switch the television to that channel should it be interesting to the rest of the group. Instead, in the lean-forward parts of the MarathOn multiscreen trial the runner videos and possible sightings were used as a mechanism to move content from one display to the other.

The resume feature of the Olympic Companion Application offered users the desirable opportunity to perform ad-hoc scheduling of content as the situation unfolds in the highlight feeds. Subsequently there may be opportunities that build on this functionality, especially in relation to complex sequencing of sports events observed in the participant groups, such as group 10s queuing up the next event on the tablet before switching the television to it at the next opportune moment. These opportunities were offered to users by the MarathOn Multiscreen Application that included

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<sup>1</sup> The term micro scheduled was first made apparent to me during Dick Bulterman’s keynote presentation at TVX2014 (Bulterman, 2014). It has not to my knowledge appeared in print, however accurately describes the behaviour of participants with the Olympic Companion Application.

interactive mechanisms allowing them to collaboratively generate playlists of events and content they wish to see.

The ecology of tablets utilised in both studies were "fluidly" coupled (Terrenghi et al., 2009). This, in theory, allowed users to make use of as many tablet devices as they desired. The evaluation of the Olympic Companion Application suggests a relationship between the availability of tablets and sociality. Where viewers were sharing the tablet between them there was an enhanced sense of sociality, more sharing and discussions. Therefore, restricting the number of tablets that can be used in a given situation may give designers the opportunity to play with the social dynamics of the viewing groups. Terrenghi et al. discuss that by establishing the design space for an application, the scale of the ecology is also defined. The findings from the Olympic Companion application mirror this idea, suggesting that being able to tailor the ecology to specific numbers of devices may be helpful in informing the design of effective systems that respond to their users.

The next guideline explores how users understood their place and the devices within the display ecology offered by the applications.

User Awareness of the ecology and Respect the television

**Guideline 4:** *The television remains central to the viewing ecology, however its and other devices roles change depending on the nature of the tasks users are engaged in. Feedback to users needs to be carefully considered given the task being undertaken and the fluidity of the ecology.*

In both the MarathOn Multiscreen and Olympic Companion Application studies the television was the centre of the application's display ecology and the social hub of viewing for users. The big screen allowed users to share and review video footage between the group as a whole, in ways not possible with the intrinsically private display of the tablet devices. The subtleties of usage and coordination of the devices in the ecology however, were characterised by the tasks and modality that users were engaged with. Similarly, in her descriptions of NASA mission control rooms, Elaine Huang

uncovers that the use of display systems evolves over time with the tasks and experiences of users, through which she coins the term display ecology (Huang, 2006).

The television has long since been considered as a cornerstone of domestic life and plays a key role in the social environment that surrounds it. Not only does its physical presence in a room play a part in the home so does the content that is broadcast through it (Silverstone, 2004). Silverstone's descriptions of the TV in the domestic environment describe it as a slowly evolving landscape. While a minority of participants from the Olympic Companion Application responded negatively to the intrusion of the tablet into their television watching practice this was not a view shared by all. For many though, more ready to accept the opportunities of many-screen viewing, the television was still principle within the hierarchy of viewing devices that users interacted with. The big screen was always the preferred place to watch the most significant events and exciting moments.

Users of the Olympic Companion Application however, struggled to understand which of them was controlling the TV when presented with a range of devices all of which were capable of making these changes. In preceding HCI literature on awareness, Bier & Freeman (1991) suggest the concept of per-user feedback, highlighting the user making changes on the communal display groupware device. Projecting which user or device initiated an action on the television is a potential solution to this problem. However this raises further design issues for multiscreen television where users are not prescribed use of a single tablet. Instead the fluid ecology of devices means that any user could be using the device, and other devices can be added at anytime. Therefore, the feedback offered to users on who has completed which action is more complex to implement. In addition, the Olympic Companion study findings include several examples of 'bad behaviour' by some participants, exerting too much control on the television, other participants observed that this might arise in 'real life' situations such as squabbling children. Future work could look at design solutions that mitigate



this kind of conduct and better democratise viewing between the group members through user feedback on others actions. Users of the MarathOn Multiscreen Application suffered similar feedback issues with the application and this led to duplicate tags of Jason being created. These issues are discussed in the next guideline.

Usage of the television and interaction differed between the two modalities of lean-forward and lean-backwards, during the MarathOn Multiscreen study. While leaning backwards and watching the breadth of content, professional video dominated the television. The editorial polish and high quality camera work marked it out as fitting better with the communal display. Decisions around whether to share spectator content during this modality were more involved and often entailed viewing the content first on the tablet to decide what was interesting and worth sharing with the group. During the lean-forward part of the trial the large scale and communal aspects of the television were utilised to aid with Jason tagging, where the TV allowed users to all look together. Therefore being able to swiftly move content between the devices became important to users.

The relationship between the tablets necessarily evolved with the changing characteristics of the activities users engaged with, when leaning back and watching or leaning forward and tagging. The introduction of a shared playlist and interfaces of runner videos caused some users issues with understanding the reach and implications of their interactions. This is a particular challenge for developers designing applications such as MarathOn Multiscreen. When is it appropriate and understandable to include interfaces that include a shared dataset between devices? In addition, how can these interfaces functionality be best articulated to users to avoid confusion and wasted effort?

Acknowledge Liveness and the Impact of Spoilers

**Guideline 5:** *Liveness of viewing should be reported clearly to users. Multiscreen viewing adds new complexity to spoiler avoidance.*

Olympic Companion users were observed struggling to establish a sense of whether they were watching live or whether they were watching from an earlier location in the programme. As discussed in the previous two guidelines, these issues might be ameliorated by improved feedback to the user, informing them whether they are watching live and any impact this has on fast-forward functionality. Issues of liveness are pertinent only to the Olympic Companion Application, as MarathOn Multiscreen did not include the ability to watch back videos live, nor did it provide programming as an unfolding schedule of feeds.

Issues of liveness led to instances where viewers were potentially seeing spoilers on the television of events they had yet to see on the tablet. Spoilers and the rise of Internet journalism and fandom have been covered in communications literature. Jenkins (2008) discusses how the convergence of television programming and Internet communities has made avoiding and uncovering spoilers a key part of the television experience for a subset of viewers. The impact of spoilers has also been investigated by HCI practitioners, some of this work has focused on the sports genre, given the distribution of PVR systems and social media services Nakamura & Komatsu (2012) and in an earlier work Nakamura & Tanaka (2007) offer a method of blocking the results of key sports event from web browsing until a user has had an opportunity to catch-up. Other work has focused on hiding spoilers from social networking sites, such as Twitter (Golbeck, 2012)

The immediacy of the second screen in combination with the social environment they are embedded in offer new opportunities for spoiling. The findings from the Olympic Companion Application suggest that spoilers can come from other places, where multiple users are simultaneously watching the same programme, at different points in the narrative, on different devices. For example, two collocated users watching the same feed at different times, one user may have seen the results of a race on the tablet, while the other is watching several minutes behind on the television, if they go to look up the race roster they should not be presented with the results because the system

has presumed it has already been watched. Designers of many-screen apps could use a number of strategies to reduce the possibilities of users seeing spoilers. This could be through notification, alerting users to points of content which they have yet to see the full context, alternatively providing adequate structure to content which limits opportunities for users to mistakenly see result to things they are yet to watch. With content that is projected on the public display of the television, spoiling solutions become more complex as not all users might have seen the required content to understand the context of commentary or are deliberately shielding themselves from results and score lines. Design solutions here might include blocking certain content from the display until all users have caught up or providing adequate warning that spoilers are forthcoming to users.

#### Complexity of Gesture and Attention

**Guideline 6:** *Measuring attention and recognising gesture are more complex when recognising the social situatedness of multiscreen television.*

O'Hara et al. (2007) reflects on the complex uses of personal mobile devices and their utilisation with video, in the home. They found that often the experience of watching is not limited to the individual user, but is shared in complex ways. Participants from both studies were witnessed behaving similarly both with video content and the statistical feeds in the applications. While a one to one mapping of user to device was not necessarily prescribed by the study methodologies the sharing of content between participants and the ways in which they were observed to do this was categorically not. Users from both the Olympic Companion and MarathOn Multiscreen were seen shifting focus between displays as they were directed towards content by colleagues, moving in closer to one another to see the relatively small screen of the tablet, or it would be held aloft by users to show others what they were seeing.

This has implications for technologies that try to track the viewer's gaze or integrate gesture with second screen interaction. Prior work in the television literature has focused on attention as an important factor in measuring the

impact of programming and advertising. Often these investigations have used gaze tracking as their principle methodology (see Hawkins et al., 2002) for an overview of communications studies on attention and gaze). More recently, gaze detection has been employed for conducting research in multi-feed sports broadcasting on a single screen (Cummins et al., 2011) and second screen systems (Holmes et al., 2012). Looking towards the deployment of many-screen television systems such as the two studies conducted here, this line of inquiry is evidently a useful direction and one that we can be confident will continue in future work. For example, a deeper understanding of attention to the different displays and relative gazes to the different devices, could help to understand the kinds of content appropriate to the different display types. However, it was also observed that the sharing of content and focus on devices was embedded within the complex social setting of viewing.

Prior work by Dezfuli et al. (2013) integrated a gesture based interaction with the second screen, allowing users to pose their responses to sports video clips. In applications such as this or in others that make use of complex vision systems to obtain interaction from the user, such as those proposed by Marquardt (2011), the system will be required to untangle the mix of social queues, attention and gestures involving the smart devices. The findings from the Olympic Companion study shows a complex picture of how content is shared between participants, the movement of tablets devices and the roles they take within the ecology. Design opportunities for fostering and further developing gesture and gaze based systems will come from a deeper understanding of the way content is shared between users and attention and gesture are directed at different devices within a local ecology.

#### Professional and Amateur

This guideline and the subsequent final guideline centre around the use of amateur content and multiscreen television therefore are only of relevance to the MarathOn Multiscreen Application, as the Olympic Companion did not include any crowd-sourced content. While the guidelines as presented here relate to the two studies on multiscreen viewing. The assertions on

investment in content and embarrassing user generated footage may well generalise to more general crowd sourced video applications. However, this would require further experimentation to determine.

**Guideline 7:** *The value attached to crowd-sourced video consumed in a multiscreen ecology is linked to personal investment in its content. Organisation of user-generated footage is tightly linked to context.*

The quality of the professional video footage was starkly contrasted for users of the MarathOn Multiscreen Application by the variability of the amateur footage, which at times was shaky, poorly framed and badly exposed. These factors had a negative effect on many user's enjoyment of the crowd-sourced video and the value that they attached to it. However, user investment in the footage and the task at hand had a positive effect on how the amateur video was perceived.

Groups who had an investment in the video were less concerned with the quality of the video, regardless if they had recorded it or not. This was either because it represented their experience of spectating the marathon or for runners of the race if the footage contained a clear of their run. Groups without this investment in the race struggled to see passed the handheld blur and framing of the crowd-sourced video and preferred to watch the professional footage. Organisation of this content, both for invested and uninvested groups, provided important structuring for the viewing and tagging tasks. Several of the users suggested, prior to seeing the map for the tagging task, that a locative interface would help them to select the amateur video footage they wanted to see. In addition, group I10 which was made up of three race runners, preferred an organisation scheme that would show the run times of runners that the video contains. Allowing them to select footage based on the quality of runner or to look out for footage of themselves given their completion time. In the lean-forward part of the study, where some of these features were available to users, the amateur content was better received and users were effectively able to navigate the content. Future iterations of the MarathOn Multiscreen Application could use the map

interface in both lean-forward and backward modalities to enhance user navigation of the content. This interface could additionally contain mechanisms by which users can filter the footage by runner time also.

While these suggested enhancements could aide in user navigation of the MarathOn Multiscreen Application, these directions would not transpose to other similar applications operating in different domains, which do not have the same design constraints. For example, stadium based sport spectating (Dezfuli & Günther, 2013) or reconstructing amateur footage from music concerts (Vihavainen, 2011). Therefore, this guideline recommends that presentation and organisation of crowd-sourced video should be a foremost consideration when consulting users as part of the user centred design process.

#### Public and Private and Avoiding Embarrassment

**Guideline 8:** *Offer users the opportunity to privately review content within the viewing ecology on a personal device. Be wary of automatically sharing sensitive content that may cause user embarrassment.*

Avoiding embarrassment from the crowd-generated content was a concern for several participants of the MarathOn Multiscreen Application. While the communal display of the television was the preferred location for viewing professional content and searching for Jason, users had a more complex relationship with video that they had shot, or where they were the subjects. For participants from some groups, the opportunity to share the video they had taken along the marathon course was seized upon and users wanted to share this on the television. Likewise if a group member, who had run the marathon, was featured or believed that they might be in some of the footage, this video was presented publicly for the whole group to see on the television. This behaviour was not universal to all the participants however, with members of group I3 wanting to vet their videos before it was okayed for watching publicly. In one instance, participant I93 completely refused to watch any of the footage she took at the marathon, believing it to be of poor quality and limited in length. The opportunity to privately watch footage

before sharing with the rest of the group was enabled by the ability to watch video footage on the tablet as well as on the television.

Public display literature has explored embarrassment with interacting in a public space (Bedwell & Carauana, 2012) (Davies et al., 2014). Additional work from cultural studies such as Bragg & Buckingham (2004), has explored embarrassment of watching sexually explicit content on the television within the family. In HCI however, less has been written about how embarrassment is dealt with within user-generated content. In a previous study that I led (Anstead, et al., 2012), the impact of embarrassing photos was compared between family and friendship groups that had been taken at a day out at a theme park. While it was observed in this study that users from family groups embraced embarrassing photos as part of the experience, the work concluded that the inclusion of embarrassing footage in souvenirs can negatively impact an individual's public image. This was particularly true of users who came from friendship groups, rather than family groups. In the MarathOn Multiscreen study we observed participants being equally cautious toward footage they were invested in.

Successful designs for multiscreen systems that include personal footage should ensure that there are opportunities for users to watch footage back privately before being shared with the group on a shared display. A future system could take this notion one stage further offering more rigorous protection for user embarrassment, potentially presenting interactive mechanisms for users to be able to pull content from either being viewed publicly or from being used in lean-forward task such as tagging and ranking.

## PRACTITIONER VALIDATION OF GUIDELINES

Having established the set of eight design guidelines presented above, the remaining part of this chapter discusses a validation exercise that was conducted using the guidelines. A group interview session was conducted with user experience researchers and research engineers from BBC Research and Development to uncover the implications of the guidelines for practitioners working within the broadcast industry.

### Aims

The principle aim of the group interview session conducted at BBC R&D was to gain industry insight into the design guidelines derived from the Olympic Companion and MarathOn Multiscreen user evaluations. The intention of this small-scale validation exercise was to determine practitioner reflections of the guidelines for the television industry. Questioning and discussions during the interview were designed to ascertain how the guidelines converge with current industry thinking on multiscreen television and the challenges of implementation within the broadcast environment. In addition, the interview concluded with questions to uncover BBC researcher opinions on the future of multiscreen television.

Chapter Three highlighted the unique place of the BBC within the broadcast industry and the compelling location it offers for conducting television and user experience research. However, as with the design of the Olympic Companion Application, the findings and reflections of this validation exercise should be viewed with the knowledge that participants' experiences are based on public service broadcasting. Acknowledging that their opinions will be framed by a different set of tensions from professionals in equivalent positions employed by a commercial broadcaster.

The following section outlines the method that was used for the group interview, this is followed by reflections taken from audio transcriptions of the session presented with practical implications for the design guidelines.

### Method

6 specialist researchers working at the BBC completed the group interview. Five of the participants are employed within BBC Research and Development and one, participant B5, is conducting a secondment in the department. Table 7-2 attaches an anonymised code to each of the participants who took part and states their role within R&D.

<b>ID</b>	<b>Role</b>
B1	UX research engineer



B2	Senior research engineer
B3	UX research lead
B4	UX research engineer
B5	Research associate (secondment at BBC R&D)
B6	Research and development engineer

Table 7 - 2 Industry Interview Participants

Participants were approached to take part based on their previous interest in the Olympic Companion Application during my internship with R&D, or interest in second screen interaction or tools. In all 12 members of staff were contacted to take part.

The group interview was conducted in November 2014 at the BBC's facilities in MediaCityUK Salford. Participants B2, B4 and B6 work out of the R&D's London office and joined the session through a video conferencing system. Both local and telepresence participants were audio recorded for the duration of the session.

The recording was partially transcribed at the conclusion of the interview for presentation of relevant quotations. These quotes highlight the themes and direction of discussions at the interview. The data was organised by the discussion, which mapped onto the guidelines set out earlier in this chapter. As such no coding of the data was required and the results presented in the next subsection are organised by discussion point.

Before the start of the interview, the session aims, the anonymisation process and data capture method were outlined to the participants and they had the opportunity to ask any questions about the session. This was followed by an introduction to the two applications or reminder of their functionality to those already familiar with the work. The interview was divided into four discussion points that were grounded in the eight guidelines presented earlier in this chapter. The interview lasted for a duration of around 90 minutes. 90

minutes is the maximum recommended duration for focus groups as it ensures participant focus and attention throughout (Morgan 1997), this requirement was transposed to the group interview method used for the validation exercise. In addition, the participants were busy professionals and the duration negotiated reflected their availability. The limited duration meant that not all guidelines could be discussed individually at the required depth, so the session was instead structured around four discussion points. Each discussion point was presented to the interview group, outlining the findings and guidelines that informed them. One or two questions were presented along side each of the discussion points, participants were encouraged to talk freely about the point and the issues raised, however the questions provided a mechanism by which to keep the discussion moving, should participants have not engaged fully with the points, or to return discussions to the key topics should conversations veer. In not all instances were the questions therefore directly responded to by participant discussions.

#### Interview Discussion Points

In order to fit the 90 minutes available for the interview session the eight guidelines presented at the start of this chapter were paired up to four discussion points to guide conversations and ensure relevance with the aims of the study presented above. The following section outlines each discussion point, questions posed to participants and the design guidelines the point is derived from.

The First discussion point centred on guidelines one, four and six and summarised discussions about viewing across devices in parallel with other collocated viewers, and system and user awareness of the ecology. Study participants saw supporting parallel viewing as a useful feature of the Olympic Companion Application, however users struggled with conceptualising the bounds of their control over the television. In addition, the complexity of sociality and sharing may have an impact on the recognition of attention and gesture.

Discussion Point	Guidelines	Questions
1. Parallel viewing and awareness of the device ecology	<p>Guideline 1: Supporting parallel viewing across devices is a desirable feature of a second screen application, especially when broadcasting a multi sport tournament. However, this raises new design challenges for the delivery of audio streams.</p> <p>Guideline 4: The television remains central to the viewing ecology, however its and other devices roles change depending on the nature of the tasks users are engaged in. Feedback to users needs to be carefully considered given the task being undertaken and the fluidity of the ecology.</p> <p>And</p> <p>Guideline 6: Measuring attention and recognising gesture are more complex when recognising the social situatedness of multiscreen television.</p>	<p>Question 1: Viewing video programming on a second screen simultaneously with the television has implications for the playing of audio on multiple devices at the same time. What types of content are best suited to audio free delivery and what features are best used to add context without audio (i.e. On-screen graphics or subtitles)?</p> <p>Question 2: In both studies users were observed to share content in complex ways, what are the implications for studies and applications that analyse user focus and attention?</p>

Table 7 - 3 Discussion Point 1

The second discussion point focuses on guideline three, the use of novel mechanisms to schedule content across the viewing ecology and asked interview participants to consider possible interface designs for improving user feedback. Discussion point two also considered guideline five on the impact of liveness and spoilers on users watching.

Discussion Point	Guidelines	Questions
2. Scheduling Queuing, Sharing and Liveness with a device ecology	<p>Guideline 3: The scheduling and queuing of content playback between devices can be enabled by a range of novel mechanisms, such as resume playback, jump to event and playlists. The scale of the ecology affects sharing of content.</p> <p>Guideline 5: Liveness of viewing should be reported clearly to users. Multiscreen viewing adds new complexity to spoiler avoidance.</p>	<p>Question 1: Users' understanding of when they were watching a 'live' broadcast and what they had and had not already watched caused confusion during the Olympics study. What interactive mechanisms could be employed to make sure users avoid spoilers (i.e. Augmenting scrub bars or using warnings and notifications)? What are the pros and cons of these approaches?</p> <p>Question 2: What are your opinions on 'micro scheduling', such as a user might do when watching events like the Olympics? What are the implications of this on the production and broadcast of television programmes?</p>

Table 7 - 4 Discussion Point 2

Discussion point three's focus was on guidelines seven and eight, both of which consider the impact of user-generated content on multiscreen viewing. Participants were asked to consider interfaces that organise user-generated content for a hypothetical application. In particular, the ways in which user-generated content is moderated before public review and could these methods be use to counteract user embarrassment.

Discussion Point	Guidelines	Questions
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3. Integration of amateur content into television programming	<p>Guideline 7: The value attached to crowd-sourced video consumed in a multiscreen ecology is linked to personal investment in its content. Organisation of user-generated footage is tightly linked to context.</p> <p>Guideline 8: Offer users the opportunity to privately review content within the viewing ecology on a personal device. Be wary of automatically sharing sensitive content that may cause user embarrassment.</p>	<p>Question 1: The marathon Application used a map and a list interface to organise the crowd-sourced content. Thinking about a hypothetical wildlife programme second screen app, where viewers send in videos of animals in their garden. How could those videos be presented to users on a second screen device?</p> <p>Question 2: What moderation tools could be used by applications with lots of user-generated content, such as the MarathOn app. Could any of these principles be applied to domestic privacy and to avoid user embarrassment.</p>
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Table 7 - 5 Discussion point 3

The fourth and final discussion point mapped directly to discussion point two and the integration of lean-forward and backward tasks in television viewing. Participants were asked to reflect on whether they believed this to be a positive intervention into television viewing and the features of the television make it appropriate for lean-forward viewing.

Discussion Point	Guidelines	Questions
4. Implications of integrating lean-forward and Backward activities in television interaction	Guideline 2: Second screen and multiscreen introduces the lean-forward modality to television watching. Lean-forward tasks may require user strategies or system	Question 1: Do you think the inclusion of activities and tasks, such as those introduced in the MarathOn app is a good thing?

	enforced strategies for coordinating groups to complete tasks.	Question 2: What features of the television make it a good interface for lean-forward interactions, when used with second screen applications?
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Table 7 - 6 Discussion point 4

### Practitioner Reflections

In this section the findings and discussions of the group interview session are reported. The subsections below reflect each of the discussion points that were raised during the interview. Each subsection includes practical reflections for the design guidelines presented earlier in this chapter.

#### *Discussion Point 1: Parallel viewing and awareness of the device ecology*

**Guideline 1 reflection:** *The Augmentation of mute video with subtitles may cause cognitive issues while parallel viewing. Utilising block subtitles might ameliorate this problem and could be an avenue for future research. In addition, the social issues of wearing headphones maybe relieved by use of bone conduction headsets*

Participants at the interview session first responded to the issues around parallel viewing. Participant B5 suggested that sport is “a good use case” for content that does not need complex audio narratives to follow all of the action. Participant B3 added that while the integration of video on the second screen is perhaps an “edge case” for companion application content, it is one that has yet to receive significant attention in prior research. He defers to B1 has experience of research into subtitles, one of the possible solutions posed by the discussion point question one. B1 has concerns about the additional mental load that subtitles place on the user and that much of their recent work into subtitles is attempting to reduce this cognitive work. Prior literature from educational disciplines, have investigated the use of visual text to support multimedia presentations and assessed students learning (Kruger et al. (2013) as a recent summary). These articles paint a complex and

contradictory picture of the cognitive load placed on individuals based on their learning outcomes, however it has been observed in numerous settings that subtitling decreases knowledge retention and therefore increases cognitive load (For example, Mayer et al. (2001)). B4 poses replacing minute-by-minute subtitles that accurately reflect the words spoken on screen with block subtitles that give an overview of the action and update more slowly to ameliorate the cognitive load problems. She suggests this approach as a solution for public display installations where the environment is challenging for all to hear the audio track, however the ideas could be transposed to a domestic multiscreen setting.

B3: It's probably under represented, a whole research space when the companion content is video. Because it's probably an edge case but it is probably an important edge case, but it's not been looked at for various reasons. In that case [avoiding use of headphones] is it mute video, what is the design space?

[...]

B1: In terms of subtitles it's an interesting idea doing them on second screen as well as video. I think we sort of assumed in some of our research that subtitles are always some kind of mental extra load on the viewer. A lot of our research has been trying to reduce the distracting effects of subtitles and having that, as a trade off with the multiple audio is an interesting area.

B3: [...] At some point the brain is going to complain, it's a bandwidth issue.[...]

B4: The subtitles on a second screen I suppose if you were in a public place, you could have video but muted video on the big screen then you could have some sort of text on the second screen. Then you could have minute-by-minute subtitles or just complementary text to make you understand the scenario.

Participant B3 concludes discussions on parallel viewing by stating that current interest for them in this area is on rendering the headphones “effectively transparent, using [technologies] like bone conduction”, allowing the user to hear content through the headphones and still be able to hear people in the room. Bone conduction headphones work by transmitting sound to the inner ear through the skull, instead of blocking the ear canal as traditional headphones require (Walker et al., 2005), this technique has recently been employed in the ‘Google Glass’ wearable headset. B3 further

suggests that it is not necessarily impossible that both devices “couldn’t usefully deliver audio”.

**Guideline 2 Reflection:** *Control issued from the second screen to the television has not received significant industry attention because of infrastructure challenges. However, the deployment of technologies, such as ‘Chromecast’, provides mechanisms to enable this interaction more easily.*

The other issue in this discussion point that was considered by the participants was user confusion over control. B3 questioned how much traction television control, issued from second screen applications, has had in developments thus far. B2 suggested that there has been little movement towards this functionality from broadcasters as it is difficult to integrate with current television hardware and building systems that implement it are currently only part of lab based experimentation. However, he does suggest that technologies like Google ‘Chromecast’ (Google, 2015) have the potential to deploy systems that control content on the television from the tablet with less of these issues. The ‘Chromecast’ device plugs into a spare HDMI port on a television and allows video and web content to be streamed from a compatible smart device or PC to the television.

### ***Discussion Point 2: Scheduling Queuing, Sharing and Liveness with a device ecology***

**Guideline 5 reflection:** *The use of notifications to alert users to spoilers in the narrative is currently the preferred route of enquiry. Augmentation of scrub bars presents a number of technical and social challenges to designers and organisations.*

The participants considered several possible ideas for mitigating the problems of spoilers and keeping track of users’ progress through different programming across the ecology. B3 recalled earlier discussion about the Olympic Companion application and the “risk of being off time, across the two displays” and his expectation that these issues would be apparent in the evaluation. Discussion considered the role of notifications in hiding spoilers from users, alerting them to points in the narrative where key events take



place, and the value and complexities of understanding what content had been consumed by which viewers. This second point was seen as a major hurdle to the use of augmented scrub bars and navigational aids that have a prior knowledge of what has been watched.

B3: "There are two problems there, there is how you represent it and how you ensure that data that underpins the representation is correct"

B5: "So fundamentally both require the tablets to be aware of the other tablets [...]"

B3: So perhaps there needs to be some sort of database effectively of viewedness, a triple store between stuff and time and eyeballs".

B2: [...] It may just be me but I would rather not have a very detailed breakdown of my exact viewing habits [everyone laughs].

B3: We have a PhD student looking at notifications and second screen and when they should be and which screen should they be on. Primary or secondary, already some interesting things coming out of that. We have much more design space for how we might alert people visually and auditorily.

In the above quote B3 also distilled the problem space into two, the on-screen representations of what has already been viewed, which will increase in complexity with the number of viewers, and ensuring the validity of the underlying database that defines what has been watched and by whom. B2's comment about not wanting to have his viewing habits known and stored, whilst intended to be humorous in the interview setting, highlight important considerations about privacy in the home. Choe et al. conducted a survey of user opinion of the augmentation of the home with sensor networks, logging of media use was one of the issues users were most concerned about (2011). Respondents did not want to have the programmes they watched or the duration they watched to be recorded and seen by other members of the household. In addition, the use of connected sensors logging TV watching behaviour has been the focus of negative media attention, such as the Microsoft Kinect sensor, attached to the Xbox One console (Andrews, 2013).

An extra layer of complexity regarding the recognition of points in a programme that might lead to spoilers was put forward by B2. He suggested that the act of highlighting features in the narrative, where there might be a

spoiler, indicates to a viewer the turn of events. However, he also proposed that with a sports narrative this might not be a bad thing, allowing users to quickly jump to key moments. B3 added to this by highlighting the complexities of understanding how to identify those points in the narrative that could be called spoilers.

B2: "The other problem you might have is that seemingly you only signal it when it's only worthy of being called a spoiler, like in sports coverage or drama or something then you are effectively demarking where all the points of interest are.[...] For drama maybe that's a bad thing for sport maybe it's a good thing because effectively you're telling the person where the highlights are in the content."

B3: " How do you editorially specify notifications and alerts, what constitutes a spoiler, what constitutes an exciting bit [...] I think it is hard, identifying it is hard, maybe do it with automatically recognising semantics or crowd sourcing."

Participants at the interview session suggested that the use of notifications, to inform users when they maybe about to receive a spoiler, is a more relevant line of inquiry for them at this time. The use of notifications while watching television across multiple displays is a current focus of work being carried out by BBC R&D, determining which screen and method is best to alert users while watching.

***Guideline 3 reflection:*** *Micro scheduling presents challenges for broadcasters used to producing long form programming.*

During this discussion point participants also discussed the micro scheduling behaviour of viewers and how it varies from more traditional means of choosing what to watch on the television. Participants were in agreement that this is a desirable interaction but were concerned about how that fitted in with the traditional means of editing and producing high quality television. For example, B2 stated that the main challenge he foresaw for that behaviour is curating short clips of content and ensuring they made sense without the context offered by music and voice over. He highlighted the role of the presenter in presenting a seamless narrative:

B2: You've got presenters whose job it is to smooth over the joins and making everything a seamless continuous narrative. Even if you just want to slice a clip, where can you actually slice from and to.[...] So can you take a clean feed, especially for a live thing like that [the Olympics]."

B2 suggests taking a clean feed from the content for use in micro scheduled applications. Provided without on-screen graphics and commentary to be used as clips in 'mashups' generated by users.

### ***Discussion Point 3: Integration of amateur content into television programming***

***Guideline 7 reflection:*** *Regional location and community are additional metrics for attaching value to user-generated footage. From an organisational standpoint the solicitation of footage from viewers is limited to specific topics and requests, therefore limited categorisation is required for preparing footage for broadcast or online posting.*

In the third discussion point participants were asked to consider how they would attribute value to user-generated content, whether that value be to an individual user or to a broadcaster such as the BBC. The dual factors of quality and personal investment discussed in guideline seven above were agreed with by the participants, B3 added that he saw a significant challenge in picking this valued footage out of the large amounts of content generated.

B3: "It's a question of accumulative value, you can add value by making it pretty or properly edited or professionally made, or it looks like rubbish but because your granny's in it or you shot it and all that. It's quite a straight forward heuristic. [...] I don't know, UGC people are going to point their cameras at any old nonsense, it's very hard to pick value out of it."

Participants also suggested that the locative nature of the footage was another factor in what value can be attributed to crowd-sourced video. B4 added to this that the inclusion of a community angle also attributes local interest to the footage. In addition, that this can also encourage users to obtain more footage from their immediate surroundings.

B4: "Make the content relative to others in your area, so there are sparrows nesting in Nottingham, so that could be highlighted. Or available in your area to photo later yourself."

The classification of user-generated video, for programmes such as 'Autumnwatch', was not seen as a particular problem for the broadcaster. Participant B2 stated that the process by which footage is accrued performs the filtering on the content.

B2: "The thing to remember about something like Autumnwatch is that they solicit content from viewers, so the degree of classification there is limited. If they are say asked to send in pictures of sparrows"

**Guideline 8 reflection:** *Embarrassment is not seen as an issue for broadcasters because review is conducted by users before submitting for inclusion in a programme or website.*

Participant B5 questions the issues around embarrassment and that the submission process would allow users to filter out content they are concerned about. From a broadcasters perspective a process of user-generated content submission is undertaken by viewers, either to the broadcaster directly or to social video site, this mitigates the problem of users not wanting to share content as they have actively chosen to do so.

B5: I'm not sure how big an issue the embarrassment thing is. Surely that's just a fundamental part of the submission process."

Applications like MarathOn Multiscreen however, act as that first point of review, for content that had previously not been watched by the users on their mobile device.

#### ***Discussion Point 4: Implications of integrating lean-forward and backward activities in television interaction***

**Guideline 2 reflection:** *The participants agree that the framings of lean-forward and backward are useful descriptors for different types of interaction with television content. The movement towards interactive tasks involving the television is regarded as a positive step for the industry. However, lean-back viewing can be disrupted by intrusive notifications and calls to action.*

The notions of lean-forward and lean-backward have been used in prior work conducted by members of BBC R&D to describe types of interaction with the television and interactive television content (Vinyagamoorthy et al., 2012 and Jain et al., 2013). The first discussion point question required participants to consider whether they believed that a (partial) transition from a lean-backward to forward style of interaction with the television was a positive step. B3 agreed that it is, and that there are a number of interesting use cases that ask questions of interactions with the television.

B3: “Yes I think it opens up a whole new load of use cases. So that’s a motherhood and apple pie question. I think in terms of lean-forward and lean-backness, it certainly must pull people away from lean-back [...] in a family situation are you engaged in the same task. Are you doing it competitively, are you doing it collaboratively and all those questions.

Participant B5 added that he thinks in a distributed multiscreen environment that the television offers a “centre for coordination”, the public nature of the television can be used to give a coordinated view of what the assembled users are doing. B3 continued that he believes lean-backwards interactions are “a fragile concept”. One that is easily broken by interactivity getting in the way of relaxed viewers. He suggests that the design of second screen applications can include mechanisms to notify and engage, but also allow viewers leaning back to ignore and continue watching.

### ***Multiscreen Futures***

In concluding the group interview participants were asked to reflect on their thoughts with regard to the future direction of multiscreen television and the interaction of user-generated content. B4 talked about the present perspective that is being adopted by BBC R&D, which is in pursuit of “commercially viable” developments. At the current time the approach being followed is the development of applications that operate in a similar manner to the ‘Autumnwatch’ application described in Chapter Three or the Olympic Companion’s stats and information feature. These apps provide users with an interactive slide show that augments the programme with synchronous auxiliary information.

B2 added to the discussion on current work by describing the technical development they are currently engaging with. He described their current work on developing 'low level enablers' for second screen without focus on a particular application type, instead developing technologies that enable "data exchange" and "synchronous presentation of content". He described the approach as not being contained to a particular programme but working across existing BBC services, including television, online and mobile applications.

B2: A second screen app for a programme is not a route we'll be going down, my guess is it'll be something a little bit more seamless and continuous. Maybe it'll be your BBC News or Sport apps, your using on your mobile or the website, will link up with whatever you are doing on the television. And will offer the relevant bits of dual screen experience when it's appropriate to do so. Be it play along with a quiz show or effectively take you to a part of the BBC website to look at some UGC videos. It's a discovery mechanism at that point.

At the conclusion of the interview B3 ended discussions with his thoughts on the possibilities of using the television for activities that are not determined by a broadcaster and enable users to switch modes from watching 'the television' to using the device as a way to interact with personal data and productivity content.

B3: The big screen in a shared space in the home is an incredibly valuable resource and it's been ours, the broadcasters to put stuff on. It's valuable resource to all sorts of people and that's a really disruptive in a good way. I'm a UGC sceptic but what I'm not a sceptic about is technology that enables users the big screen experience or dual screen experience themselves. So I think there will be a lot more of using your screen ecosystem for your own sort of stuff, whether that's pictures or personal data or productivity stuff, [...] that's just a mode. Like switching SCART sockets or something. [...] So the coexistence of broadcast material and personal material, however many-screens it spans is going to be an interesting design space. And that's not about UGC going up the chain to us.

## CONCLUSION

In this chapter a set of eight design guidelines have been distilled from the findings and discussions around the Olympic Companion and MarathOn

Multiscreen Application studies. In addition, a validation exercise with BBC Research and Development has been reported that evaluated these guidelines for relevance to the broadcast community. This evaluation concluded with a series of practitioner reflections that challenge the guidelines implementation and relevance to industry developments of multiscreen television. A summary of these guidelines and their reflections is presented in Table 8-1 in the next chapter.

The final chapter of this thesis provides a discussion of these guidelines and reflections, in respect of the questions posed by the thesis statement in Chapter One. In addition, the next chapter includes study limitations and potential avenues for future research work.

# Chapter Eight

## *Conclusion*

### INTRODUCTION

This chapter concludes and summarises the issues raised through the development of the thesis, returning to the objectives and questions posed in Chapter One. A summary of the guidelines and the reflections described in the previous chapter are presented in Table 8-1 that maps back to the overarching thesis questions. Subsequently, the content of this table is discussed and responses to the thesis questions are put forward. This chapter concludes with sections outlining the limitations of the work conducted as part of this thesis, future work direction and final reflections.

This thesis has investigated a class of interactive experiences that take place across an ecology of mobile devices, television sets and content, and collaborating users. In the introductory chapter the propagation of certain forms of interactive television was established, portraying ad-hoc functionality mediated through social media platforms and joined up experiences enabled by multimodal strategies developed by broadcasters. The focus adopted by this dissertation is to investigate the development of experiences that take place across multiple display devices. Companion applications, bespoke second screen augmentation to television



programming, are increasingly prevalent mechanisms for users to engage with programming using their mobile devices.

The current perspective of both the broadcast industry and academia of second screen television, was explored in detail in Chapter Two. Organised around a structure proposed by Cesar et al. (2008), the possibilities offered by second screen companion applications to 'control, enrich, share and transfer content'. While this review uncovered a growing area of interest, contributions addressing the social, collocated nature of television viewing were less evident.

This thesis therefore, proposes a class of companion applications that are referred to as many-screen applications, allowing interaction with television content to take place across a flexible ecology of interacting views and devices. In addition to considering the perspectives this approach places on existing second screen television literature, the prototypes developed have been informed by wider standpoints on multiscreen interaction and groupware from other HCI paradigms.

This thesis' focus on sports programming has facilitated investigations into another trend that is shaping current and future television viewing practices, the integration of user-generated video content. Through the second of the two prototype applications, MarathOn Multiscreen, the confluence of these two trends was explored.

By extension, this intervention allowed for an exploration of lean-backward television viewing, passive watching of broadcast programming and more active, lean-forward, viewing where users are engaged with tasks while they are watching. In the case of MarathOn multiscreen these tasks included, searching and sorting through user-generated content and the construction of video clip playlists.

## GUIDELINE SYNTHESIS AND THESIS QUESTIONS

Through the development of the two studies a series of design guidelines have been constructed to help inform the development of future many-screen companion applications. The introduction to this thesis laid out the following thesis aim:

**The synthesis of industrially informed and verified guidelines that support the design of ‘many-screen’ television applications that allow synchronous interaction across multiple display devices. The guidelines incorporate collocated viewer requirements in respect of both watching and organising a schedule of professional sports programming and user-generated video content.**

The ideation and development of the two applications was informed by the broadcast industry. In the case of the Olympic Companion Application this took the form of a three month internship at BBC Research & Development at MediaCity UK, where I was afforded the opportunity to engage with both broadcast researchers and sports producers working on interactive content. Inspiration for MarathOn Multiscreen was formed through an existing project funded by the online video site YouTube. In addition to the development of the design guidelines, presented in the previous chapter, a group interview with researchers working in the broadcast industry was reported. Further informing the guidelines with insights from the broadcast industry

The investigations conducted as part of this thesis were further articulated by the development of three research questions that guided the design, development and evaluation of the two prototype user studies reported:

1. *How is content shared and scheduled by users interacting with a many-screen television experience, and how does the integration of additional display devices alter the traditional single or dual screen viewing environment?*

2. *How do users appropriate user-generated video content while watching across multiple display devices, what methods are employed to sort and organise valuable footage from a wider corpus of video? In addition, what factors influence user opinion on the value of user-generated video, how does this differ from professional shot and produced programming?*
3. *Television viewing that takes place across multiple displays enables 'lean-forward' modalities. What strategies and configurations are adopted by users while engaging with lean-forward task, and how does this vary from 'lean-backward' viewing?*

The first study investigated collocated viewing with a many-screen television application. The Olympic Companion Application, allowed viewers to consume an unfolding schedule of programming across a many-screen ecology of devices, dividing viewing between the television and a number of tablet devices. In addition, the application allowed users to review statistics and information about the programming in synchronisation with television playback. During a formative evaluation, users had access to highlights of the London 2012 Olympic Games in groups of three. During the evaluation the number of tablets users had access to increased, observing change in practice and user appreciation with different configurations of ecology.

The first study predominately informed the first research question on sharing and scheduling across an ecology of second screen devices that changes in size and configuration during the interaction and asked users to reflect upon how the experience differs from traditional viewing practices. Capturing user decisions on what programming to watch when and on what device between the members of the interacting group. In addition, the application attempts to recreate the expected functionality of live broadcast, offering an unfolding schedule of programming and limiting the ability to fast-forward before content is available.

The second application studied, MarathOn Multiscreen, allowed users to engage with both professional video content and a corpus of amateur footage taken at the Nottingham Marathon. Using the application users could passively view or actively share, sort and organise amateur footage as a group. This application was subject to a similar formative user study to the one conducted with the Olympic Companion Application.

This study was principally concerned with the second and third research questions, the integration of user-generated video content and comparisons between lean-forward and lean-backward interaction. The study aimed to compare user behaviour between viewing activities. The difference between lean-forward and lean-backward was explored through two different modes, one for viewing professional and amateur video content and one for sorting, searching and selecting amateur content for inclusion in bespoke artefacts such as video souvenirs. Furthermore, the evaluation asked how does the application support users in coordinating themselves and devices while engaging in these lean-forward interaction. In addition, the evaluation sort opinions on the value of user-generated video content and its appropriation across a many-screen ecology.

Table 8-1 describes the interaction of the thesis questions, the design guidelines and practitioner reflections detailed in Chapter Seven.

Research Question	Guideline	Practitioner Reflection
How is content shared and scheduled by users interacting with a many-screen television experience.	<b>Guideline 1:</b> Supporting parallel viewing across devices is a desirable feature of a second screen application, especially when broadcasting a multi sport tournament. However, this raises new design challenges for the delivery of audio streams.	<b>Guideline 1 reflection:</b> The Augmentation of mute video with subtitles may cause cognitive issues while parallel viewing. Utilising block subtitles might ameliorate this problem and could be an avenue for future research. In addition, the social issues of wearing headphones maybe relieved by use of bone conduction headsets
	<b>Guideline 3:</b> The scheduling and queuing of content playback between devices can be enabled by a range of novel mechanisms, such as resume playback, jump to event and playlists. The scale of the ecology affects sharing of content.	<b>Guideline 3 reflection:</b> Micro scheduling presents challenges for broadcasters used to producing long form programming.
	<b>Guideline 4:</b> The television remains central to the viewing ecology, however its and other devices roles change depending on the nature of the tasks users are engaged in. Feedback to users needs to be carefully considered given the task being undertaken and the fluidity of the ecology.	
	<b>Guideline 5:</b> Liveness of viewing should be reported clearly to users. Multiscreen viewing adds new complexity to spoiler avoidance.	<b>Guideline 5 reflection:</b> The use of notifications to alert users to spoilers in the narrative is currently the preferred route of enquiry. Augmentation of scrub bars presents a number of technical and social challenges to designers and organisations.

	<b>Guideline 6:</b> Measuring attention and recognising gesture are more complex when recognising the social situatedness of multiscreen television	
How do users appropriate user-generated video content while watching across multiple display devices.	<b>Guideline 7:</b> The value attached to crowd-sourced video consumed in a multiscreen ecology is linked to personal investment in its content. Organisation of user-generated footage is tightly linked to context.	<b>Guideline 7 reflection:</b> Regional location and community are additional metrics for attaching value to user-generated footage. From an organisational standpoint the solicitation of footage from viewers is limited to specific topics and requests, therefore limited categorisation is required for preparing footage for broadcast or online posting
	<b>Guideline 8:</b> Offer users the opportunity to privately review content within the viewing ecology on a personal device. Be wary of automatically sharing sensitive content that may cause user embarrassment.	<b>Guideline 8 reflection:</b> Embarrassment is not seen as an issue for broadcasters because review is conducted by users before submitting for inclusion in a programme or website.
What strategies and configurations are adopted by users while engaging with lean-forward task, and how does this vary from 'lean-backward' viewing?	<b>Guideline 2:</b> Second screen and multiscreen introduces the lean-forward modality to television watching. Lean-forward tasks may require user strategies or system enforced strategies for coordinating groups to complete tasks.	<b>Guideline 2 reflection A:</b> Control issued from the second screen to the television has not received significant industry attention because of infrastructure challenges. However, the deployment of technologies, such as 'Chromecast', provide mechanisms to enable this interaction more easily.
		<b>Guideline 2 reflection B:</b> The framing of lean-forward and backward are useful descriptors for

		different types of interaction with television content. The movement towards interactive tasks involving the television is regarded as a positive step for the industry. However, lean-back viewing can be disrupted by intrusive notifications and calls to action.
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Table 8 - 1 Research Questions and the associated guidelines and reflections

### Question 1: Sharing and scheduling

The first research question explores the nature of sharing content between users of many-screen applications. How do users configure the limited or abundant resource of second screen companion devices and how is content scheduled between the group, to ensure everyone has the opportunity to view their favoured programming? A response to this question is summarised by the following:

*Sharing and scheduling of 'many-screen' content is a complex, evolutionary and context specific process, affected by task and ecology size. Supporting parallel viewing is a desired and used feature, allowing users to transition between public and private viewing, and schedule programming alone and as a group. User awareness and highlighting liveness is important to minimise user confusion and protect against unnecessary spoilers.*

Prior literature on second screen television, such as Cruickshank et al. (2007) and Basapur et al. (2011), are informed by the sociality of viewing yet few studies have directly investigated the sharing of multiscreen content by collocated viewers. This thesis has attempted to contribute a social perspective of multiscreen television viewing.

During both Olympic Companion and MarathOn Multiscreen studies users employed a multitude of sharing mechanisms. The ecology metaphor has proven to be a useful mechanism for describing the fluidity of the viewing environment (Nardi & O'Day 1999). In the studies users demanded that devices seamlessly and spontaneously switched roles as they were interacted with. Switching between being a one user to one tablet relationship, to a shared display allowing multiple users to consume content synchronously. This transition was important to some users of MarathOn Multiscreen, who wanted to consume the video they had shot at the Nottingham Marathon privately, before openly sharing the content with the rest of the group. **Guideline 6** discusses the complexity of automatically tracking this user behaviour reflecting on the need to understand the social situatedness of viewing before untangling the hard problems of user attention and gaze.



The sharing exhibited by users was observed to differ significantly when more tablets were available to users. During the Olympic Companion study users had access to an increasing number of tablets as the trial progressed, it was apparent from the study data that the more tablets users had access to the less likely they were to share content between themselves and the experience became more isolated. While users saw the higher availability of tablets as the more desirable configuration, several reflected on the lack of sharing when more tablets were available. The effect of ecology size is discussed in **guideline 3** along with the issues of scheduling.

An unlikely use case came to the fore in the Olympic Companion study in the form of parallel viewing, where users watched alone on the tablet while others watched the television. The issues of parallel viewing are discussed in **guideline 1**. Parallel viewing raises issues of how sound is delivered to the tablet, that neither interferes with others viewing of the television, or isolates users from the rest of the group. These issues were discussed at the expert group interview conducted at BBC Research & Development. In **guideline reflection 1** the use of headphones that do not isolate users from the rest of the room are suggested as a mechanism for ameliorating the effect of isolation. Alternative solutions were also discussed including removing the need for a sound channel with on-screen graphics. However, the use of audio descriptive subtitles was seen as cognitively too demanding when viewing on the tablet with the television playing related content in the background, such as another Olympic sport.

**Guideline 4** reflects on the role of the television within the viewing ecology configured by the two applications. The shared display was the favoured device for many aspects of users' viewing. Whether that was watching the big events of the London Olympic games, such as the Men's 100 metre race, or searching for runner clips, allowing users to search for footage together and make judgments about its quality. The multitude of control possibilities offered by the multiple tablets resulted in control issues. These problems resulted in user confusion and duplicated effort by participants. Feedback and

awareness issues are prevalent in many-screen television applications, prior work in groupware such as Bier & Freedman (1991) and Gutwin & Greenberg (1999) highlight these issues in more traditional CSCW multi-user environments. This was particularly the case for users of MarathOn Multiscreen while searching, tagging and sorting footage, where the lack of awareness led to duplicate effort between them.

### Scheduling

Users of the Olympic Companion were observed to schedule content between themselves in a variety of ways. Scheduling, in the case of the functionality offered by these applications, is the process of planning when and how to watch short chunks of content that sit within a broader programme narrative. In engaging with this micro scheduling, Olympic Companion users made use of the television controls, on both the tablet and the remote control and the resume functionality, allowing users to pick up from the playhead they were watching on another device. Users employed this functionality to switch content between devices at the appropriate part in the contents narrative, ensuring that individual preferences were served by parallel viewing on the tablet or group viewing on the television, so no one missed the action that was important to them. **Guideline 3 reflection** reflects on the difficulties of developing content to be consumed in small chunks, such as with the observed fluid scheduling by users in the Olympic Companion study, citing the difficulties of developing high quality content that may, or may not, be consumed in bite size sections. The research professionals cited issues such as interrupting the narrative flow and avoiding spoilers.

**Guideline 5** discusses the importance of user awareness, specifically issues experienced with the Olympic Companion Application as to whether they are watching live programming and how to avoid spoilers from upcoming events. Given the practical complexities of user scheduling of content across a many-screen application, the perception of liveness became a challenge for users, therefore there was an increased risk to users of finding out the result of an event they were yet to watch. These issues were reflected on in **guideline**

**5 reflection.** The broadcast professionals reflect on current interest in the use of notification alerts to inform users of potential spoilers. However, discussions at the group interview reflected on the issues of privacy. An implementation capable of delivering an appropriate notification to an individual or group of users would need to sense and retain viewing behaviour over a protracted period of time and could be potentially be a substantial invasion to a user's privacy.

#### Question 2: User-generated content

The second research question focused on the use and appropriation of user-generated video content in a many-screen viewing environment. The response to this question, through investigations with MarathOn Multiscreen is summarised by:

*User investment in amateur footage is a balance between content interest, quality of footage and the task they are engaged in while watching it. The risk of user embarrassment can be avoided by pre-screening on a private display before sharing with the rest of the group.*

Prior work on the integration of user-generated content with second screen viewing has mostly focused on the use of social networking platforms, such as Doughty et al. (2012). Sports spectating lends itself to the integration of user-generated video (Jacucci et al., 2006) the MarathOn Multiscreen Application capitalised on the possibilities of the confluence of these issues.

The MarathOn Multiscreen Application gave users the opportunity to engage with a corpus of amateur footage that was taken at the Nottingham Robin Hood Marathon. The evaluation sought user opinion on the value of the footage to both users who were invested in the footage, because they had taken it or were its subjects, and those that were keen to engage with a community event despite being uninvested in the amateur video.

**Guideline 7** explored the value that users placed on the amateur footage. As would be expected user value of the content was a balance between the quality of the footage and the specific user's investment. In addition, the task

and context of user engagement had an effect on their appreciation and how they related to the footage. While users engaged with the tagging task during the evaluation they became more forgiving of the quality limitations and the value proposition offered by the footage was positively affected. Furthermore, this guideline discussed the organisation of amateur content in the application. Design directions made apparent through the study and user opinion suggested representations would be highly context specific. During the industry group interview these issues were discussed, focusing on the locative nature of footage and the integration of amateur video in broadcast content, this highlighted a process of solicitation of clips employed by broadcasters absent in the MarathOn Multiscreen Application. These factors are discussed in detail in **guideline 7 reflection**.

### *Public and Private Viewing*

Some users of MarathOn Multiscreen, who had shot footage, were concerned about the social implications of sharing their recordings. **Guideline 8** discusses the need for users to be able to privately review their personal footage using the tablet before sharing with the group. **Guideline 8 reflection** again reflected these issues as not being important to the broadcast community, as the process of upload suggests consent to publically share footage. While this perspective holds true with current models, future iterations of applications like RunSpotRun could support upload and distribution without prior review.

### Question 3: leaning forward and backward

The final thesis question explored user strategies and configuration when engaging with lean-forward activities, such as the searching and selection tasks enabled by the MarathOn Multiscreen Application. These practices were analysed in relation to the traditional mode of lean-backward television viewing, apparent in the Olympic Companion Application study and the first of part of the MarathOn Multiscreen study. The following is a summary of this thesis response to this question:

*Lean-forward and backward are progressively useful notions for television watching practice. The relevance of lean-forward is of particular current interest, as auxiliary devices are increasingly mediating television control. The transition to lean-forward viewing may require more formal user configurations and strategy to avoid duplicated effort and user frustration.*

The framing of television watching as a lean-backward interactive experience has been discussed in the literature for some time (Nielson, 2008). However, contemporary reframing of viewing challenges these notions of watching as increasingly mediated by new forms of interactivity using the television and supplementary devices (Vinayagamoorthy, et al., 2012). The **guideline 2 reflection B** reinforces these notions, the industry professionals interviewed believed the terms to still useful descriptors of television interactions and the movement toward lean-forward viewing, in some instances, as welcome progress for the industry. **Guideline 2** discusses the implications to the configuration and strategies of viewing adopted by users while engaging in lean-forward watching. Users engaged with lean-backward watching activities, such as those featured in the Olympic Companion study and the first mode of the MarathOn Multiscreen study, were observed to successfully view without difficulties or frustrations while employing ad-hoc collaborative practices. In the lean-forward tasks of MarathOn Multiscreen users encountered more challenges with this approach, which led to duplicated effort and user frustration with the application. Similar to the challenges of user feedback and awareness posed by **guideline 4**, current notions from CSCW research may need to be reconfigured or extended to be applicable to social television viewing practices.

In addition, during the group interview session with broadcast professionals, the issues surrounding the use of second screen devices as a television control mechanism were discussed. This is summarised by **guideline 2 reflection B**. To date limited attention has been play to these issues from industry, as broadcast technology has not allowed for these systems to be widely deployed as of yet. However, recent developments such as Google

‘Chromecast’ and ‘Smart’ televisions make these discussions an increasingly relevant contribution.

## LIMITATIONS

Chapters Four and Six of this thesis concluded with limitations sections focusing on the inherent limitations of the Olympic Companion and MarathOn Multiscreen studies respectively. In this section further constraints placed on the thesis will be outlined, focusing on two main areas of limitation, the choice of programming genre and ecological validity.

The applications developed in the conducting of this research centred on the genre of sports programming. Genres are made up of specific tropes and styles that are not necessarily commuted between programme types, therefore focusing on a single genre ensured validity of comparison and analysis between the two application studies. The choice of sports broadcasting was chosen based on prior research into appropriate genres for augmentation with social interactions access to industry professionals and that sports viewers tend to be emotionally engaged and interact with the content outside of the bounds of the programme (Gantz et al., 2010). Other genres of programming are considered to be appropriate avenues for second screen research such as news, quiz shows and soaps (Geerts et al., 2008), which would have raised different sharing opportunities and modes of interaction. In addition, user-generated video content may not have applicability to all these genres.

### Ecological Validity

The Olympic Companion and MarathOn Multiscreen studies were designed to be aware of the conditions in which television content is viewed. While it would be hard to place a metric of success on this approach, users were observed to fluidly interact with one another and the content, suggesting they were comfortable in the environment and operated with agency despite the laboratory setting. This approach was chosen to maintain focus on the research questions and study objectives and allowing for users to interact with system capabilities beyond what is currently available to broadcast hardware. However, this approach could not be assumed to account for the

totality of the features of domestic life. When taking these applications out into the wild a range of unaccounted for situations will occur without the restrictions of the laboratory. For example, the studies were limited in user group size and tablet availability. In each study groups of three users were present, a study conducted in a realistic setting might investigate configurations of users engaged in the MarathOn Multiscreen tagging task with one, two, four or more users utilising a number of devices between them. Further considerations of domestic routine would inevitably characterise the results from an in the wild study, such as, distraction of other digital and physical activities in the home such as media stacking (office of Communication, 2013a).

## FUTURE WORK

This section builds on the previous section and outlines potential areas for future research based on the findings of the Olympic Companion and MarathOn Multiscreen Applications discussed in this thesis. The limitations section above focuses on two areas that influence the generalisability of results from the two studies conducted. This thesis considered a single genre of programming, sports, to inform its analysis. Future studies with multiscreen applications could look at alternative genres of programming, such as news broadcasts, quizzes or soap operas. Utilising the design guidelines and reflections presented in the previous chapter to highlight differences and similarities on sharing, task transition and integration of user content. For example, sharing news stories and choosing when, and on which device, to watch more detailed analysis of events based on individual or group interest. Alternatively, watching a quiz show with a companion application, balancing collocated users playing against one another alone or together as a team.

### In The Wild Evaluation

The second limitation discussed above, is that of ecological validity and the location and style of evaluation. The study design utilised by the two main studies of this thesis attempted to be aware of the ecological considerations of the living room while providing a platform for analysis that was responsive to

the fidelity of the research questions. Future work involving these applications, and other possible future apps, could involve taking them out of the laboratory and into the wild, evaluating in the homes of participants. This approach would lead to less focused findings, however, would allow for investigation of applications with less control over the variables, such as the number of tablets available, collocated group size and distraction by other influences, for example, the integration of media stacking with many-screen application use.

An in the wild evaluation of many-screen applications, could take on a variety of forms. As previously stated, the applications presented in this thesis are prototypes, they were not designed to be directly integrated into broadcast hardware, in their current form an in the wild investigation would involve deploying hardware into a users home and observing use in a similar fashion to the studies presented here. Alternatively more advanced prototypes could be deployed more widely, utilising smart televisions or devices such as the Chromcast. In these situations use data could be harvested from interaction logs and opinions from user surveys. In addition, ethnographies of small numbers of households could be conducted, looking at behaviour with the applications against domestic practice and routine.

In addition to the above future work seeded by the limitations section, the study discussions, the resulting guidelines and their reflections stated other possible avenues for future investigations. For example, the transition between lean-forward and backward tasks was not explored by the MarathOn Multiscreen study, as the schedule divided the two tasks, a future investigation could potentially look at the timing and factors that instigate these transitions, such as user interest in particular content or the availability and distribution of devices. In addition, the Olympic Companion study posed directions of future study with intergenerational groups and mechanisms for dealing with subversive or bad behaviour with group members.



## FINAL REFLECTIONS

The questions raised by this thesis are substantiated by a need to understand user behaviour and appropriation of television content when exposed to multiple display devices. The direction of this approach is grounded in broadcasters desire to retain relevance of their programming and a growing second screen television literature concerned with the sociality of viewing. The completion of the two studies uncovers a complex network of issues that shape interactions with these systems. Through exploration of the study findings this thesis has shown many-screen interactions to be a messy and socially intricate ecology of users, devices and content that belong to the 'wicked' class of problems (Fitzpatrick, 2003). In that, it is as difficult to determine the solutions to the challenges of many-screen television systems, as it is to determine what those challenges might be. Therefore, this thesis' insights into an underexplored paradigm are presented as a series of reflections and guidelines, and do not attempt to theorise or distil the results into an overarching framework of interactions. These reflections report on the complexity of sharing across many-screen ecologies, the fluidity of transition between lean-forward and backward, and the appropriation of user-generated content within these systems.

The Living room has become a key interactive battleground, as consumer computing devices have moved out of the home office onto the coffee table and into pockets, everywhere media consumption has challenged the stalwarts of traditional broadcasting. For over half a century the television has reigned supreme, embedding itself seamlessly into society, culture and daily life. It is the intention of this thesis to not present a future where the television is unseated by more modern digital technologies, but to present opportunities for integrated experiences that transition between connected television and mobile devices. The interactions proposed by the two many-screen applications, allows the television to work in concert with a range of personal devices, featuring both professional and amateur content that allow users to share or watch alone as they desire. The big screen has a vital role to play in these interactions and only the communal display in the corner of the living

room is able to fulfil them. For the foreseeable future landmark news events, culturally significant drama and sporting triumphs will be broadcast and consumed on the television and we will want to share these experiences together.



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# Appendix A

## *PLATFORM INFRASTRUCTURE*

In this appendix the technical details of the many-screen platform infrastructure are outlined. The infrastructure offers client and server code that can be extended to implement the functionality required for a specific application. The modular code design and use of the model view controller pattern allow for this extensibility and easy code maintenance. The framework was utilised by the MarathOn Multiscreen Application.

### COMPONENTS

The platform consists of two main components the server and base code for application clients. Clients, which import the base code responsible for implementing the functionality listed below, can operate in one of two modes, either application or television. The mode is selected by the inclusion of a <DIV> element, in the applications main HTML file. The DIV element is given a class attribute of either 'appWindow' for applications, or 'tvWindow' for television. Where an instance has been designated as television, the application launches a fullscreen video player view and playhead progress is propagated to all other connected clients and to the server to implement video feed resume functionality across the devices. In the current

implementation of the platform, only a single client can be registered as a television. Clients running in application mode offer the remainder of functionality below, with code to implement the playback and scrubbing of video, channel and feed selection, television control, and display of interactive feeds. In addition, the underlying code structure allows for implementing clients to extend this functionality through the creation of new modules, implementing code specifically for that application's requirements. Modules constructed for the MarathOn Multiscreen Application, which implement a playlist across the connected devices, the runner interfaces and interact with the RunSpotRun dataset are described in the MarathOn Multiscreen Modules subsection below.

The server component is responsible for the connection and disconnection of clients, distributing a schema of channels to newly connected clients and logging user interaction across the devices. In addition the server maintains playheads for each video feed played on a client instance, which has been setup as a television. Therefore when new application clients are registered they can be informed of where the television feed has played to. This allows clients connecting after there has been some playback on the television, to accurately display statistical and information updates without revealing spoilers and correctly resuming playback.

## FUNCTIONALITY

The platform implemented the following functionality, which can be utilised in implementing applications.

***Core Functionality is Extendable:*** The platform implements core functionality common to both the Olympics and Marathon Application, as described by this list of requirements. However the platform is implemented using a modular design and the observer pattern (described in the Design Patterns subsection), so that additional functionality, specific to a particular application, is easily incorporated.

**Connection and Disconnection:** Application instances that implement the platform can connect and disconnect to the server at anytime during execution, therefore clients that connect after viewers have watched video on the television are able to resume playback of the feed at the correct playhead. In addition the server can support connection from any number of clients and can handle unexpected disconnection and reconnection because of crashes or accidental application closure by users.

**Download a schema of channels and feeds:** Similarly to the Olympic Companion System, upon connection, the server provides a client with a schema of channels and feeds that are utilised by the application, the schema is encoded in JSON (JavaScript Object Notation). Logically content is divided into channels that contain feeds. Feeds can either be video or interactive content. Video feeds contain a URI to a video object, a name, description and thumbnail, and fields that dictate the times it is available to the user. Interactive feeds, referred to in the schema as TIC feeds, include the same fields as a video feed, with the exception of the video URI that is replaced by a list of URIs to web page content. Additionally interactive feeds can be paired with video feeds, allowing for synchronised playback with a video, facilitating stats and information functionality as seen in the Olympic Companion system. To complete the implementation of that functionality, the feed also contains a list view flag, when enabled users can switch between available pages and each page has an availability time associated with it. The schema used by MarathOn Multiscreen is described in the Application content section below and the utilised schemas for both studies are available in appendix B.

**Live Playhead:** Similar to the Olympic Companion System the code base implements a live playhead for each of the video feeds available in the channel schema. The live playhead mimics the notion of a broadcast by the playhead increasing as time passes, since the feed was made available to the user. Therefore if a user was to select a feed to playback live, 5 minutes after the feed was made available, the feed would start to playback 5 minutes into

the video. The live playhead was not utilised by the MarathOn Multiscreen Application, as the content used did not lend itself to being presented as a broadcast, the functionality was however implemented to achieve compatibility with the Olympic Companion System.

**Logging:** All user interaction is logged to the server using a consistent protocol, (also utilised by the applications message bus and observer module). The application also builds on problems with logging in the Olympic Companion application, caused by browser native HTML5 video controls, through implementation of custom video playback controls.

#### Television Functionality

The following functionality is specific to application instances operating in the television mode:

**Play a video feed:** Playback video feeds as initiated by user selection on application clients. Playback on the television application replicates the experience of watching broadcast television by displaying the video fullscreen and hiding all browser chrome from the user.

**On-Screen Notifications:** The television application displays simple on screen notifications to users, confirming feed changes, pausing, and fast forwarding and rewinding. This requirement is in response to the lack of television notifications that troubled users in the Olympic Companion application Study.

#### Application Functionality

Finally, the following functionality is implemented by instances of the code base that operate in the application mode. It is expected that applications in this mode will be run on tablet devices.

**List channels and feeds:** Enumerate the channels and feeds that are described by the schema distributed by the server. Users can select feeds and channels from this list for playback on the tablet and television. A simplified version of this list functionality, along with the television controls described below,

could be utilised in the development of a remote control application for functional equivalence with the Olympic Companion Application.

***Instigate video playback:*** Video feeds that are select by users from the feeds list can be played back on both the television and the tablet application. Subsequently, users have the option to select whether to begin this playback, from the beginning, from the live playhead or to resume previous progress from the television or the tablet. If both tablet and television have consumed part of the video, the higher playhead value will be selected to resume from. For example, if the television had played back a video feed from the start to 5 minutes and the tablet from the 5 minutes to 10 minutes, the tablets playhead would be selected to continue playback from 10 minutes.

***Playback video:*** Application instances can playback video in addition to television instances, enabling the parallel viewing user behaviour observed in the Olympic Companion user trial. The video player implementation in the Olympic Companion used the browser default controls, this generated issues with interaction logging, particularly when users scrub through the video, generating numerous seek interactions, which do not accurately reflect a users intention. Therefore video player module implements custom video controls, which override the browser default controls.

***Interactive content:*** Interactive feeds of content can be instigated and executed from within the clients identified as applications. In the Olympic Companion Application and information feeds provided by the MarathOn Multiscreen Application, these feeds consist of a series of a series of static HTML content. These pages can be enumerated in a user selectable list allowing users to select between available statistic updates. Functionality, such as the runner map and playlist in the MarathOn Multiscreen Application, which offer more complex interactive experiences, are implemented by an interactive feed consisting of a single file of content. The file contains an HTML DIV element with a class or ID field that is recognised by a custom code module that implements the required functionality. This



technique could enable the development of a range of unique applications, such as quiz shows and interactive narratives.

**Control the television:** User control of the television is conducted through tablet applications. Using these controls viewers can pause and resume the video feed playing on the television, and fast-forward and rewind.

The following subsections describe how this functionality has been implemented in modules, using a message bus protocol and a series of design patterns. The Application Walkthrough section describes in detail the implementation of the platform for the MarathOn Multiscreen system.

## DESIGN PATTERNS

To aid code reuse and organisation the following design patterns were utilised in the development of the multiscreen prototyping platform that the MarathOn Multiscreen Application is built upon:

**JavaScript revealing module pattern:** JavaScript does not provide mechanisms for code separation or package syntax, the module pattern allows for code to be organised into self-contained functional units that can be added, replaced or removed (Stefanov, 2010). A module is declared as an immediate function that returns an object this enables public and private scope, code declared in the return object has public scope and can be accessed by other modules. In the revealing version of the pattern all methods are declared in private scope but exposed in the return object (Stefanov, 2010). The division of code into modules supports easier code maintenance and application specific functionality without altering the core code base. The scoping provisions of the module pattern ensure that the core functionality of the platform is accessed safely by an implementing application. For a list of the platform's core modules, and application specific models used in the MarathOn Multiscreen Application see the Modules section below.

**Observer Pattern:** The observer pattern (otherwise known as the publisher/subscriber module) defines a one-to-many dependency between modules. Such that when communication messages are received, a single update is made to the applications state and all other modules are notified of the change automatically (Gamma et al., 1995). For example the communication messages could derive from user interaction, receiving the channel schema, or playhead updates from other clients of the application. The pattern works by observers (in this instance the core and application specific modules) registering a callback function with the subject module. When an update is made to the applications data model the subject iterates through its list of observer callback functions and publishes a message informing the module of the model change. Therefore the subject is decoupled from the implementation and number of modules, it is up to the observing module to decide if the message is of use or if it should be discarded. The messages used in the platform to inform observer modules of changes to the model are the same. The central application module exposes several functions to allow other modules to safely request update to the data model, which turn cause the subject module to iterate a message through to its subscribers. The following code snippet shows the implementation of a module and its observer callback function.

```
var demo = (function()
{
    moduleName = "demoModule";

    var observerCallback = function(message){
        if(message == "ready")
        {
            privateFunction();
        }
    }
    app.subscribe(moduleName, observerCallback);

    var privateFunction = function(){
        console.log("this is the private
function");
    }

    var publicFunction = function(){
        Console.log("This is a public function");
    }

    return{
publicFunction: publicFunction
    }
})();
```

The demo module implements three functions the observerCallback function is registered with the observer patterns subject using the call to `app.subscribe(moduleName, observerCallback)`. When the observerCallback function receives a message from the subject it is compared with the message 'ready', if the condition is matched the privateFunction is called and displays a message to the browser console. The final function, publicFunction is made

available to other modules in the application by including a reference to it in the return object.

**Model-View-Controller:** The model-viewer-controller pattern (abbreviated to MVC) is implemented using the Observer pattern and ensures division between the underlying data model used by the application and its presentation to the user, using controller objects or modules as a go between (Gamma et al., 1995). Again the MVC pattern helps making code readable and extendable. The platform's model has two parts an application model, which is received from the server at runtime, and the internal model, derived from the application model but is updated with playhead values and application specific functionality. The majority of modules are controllers communicating with the application and internal models using their observer callback functions, handling user interactions with the application or responding to playhead events. Application views are implemented using a templating language, in this case EJS (EJS - JavaScript Templates, 2014). JavaScript templating allows for executable code to be included in HTML markup, therefore the views are dynamically generated at runtime in easily maintainable code separate from the controller modules. The following diagram shows the relationship between model and controller modules, and templated views in the multiscreen platform.

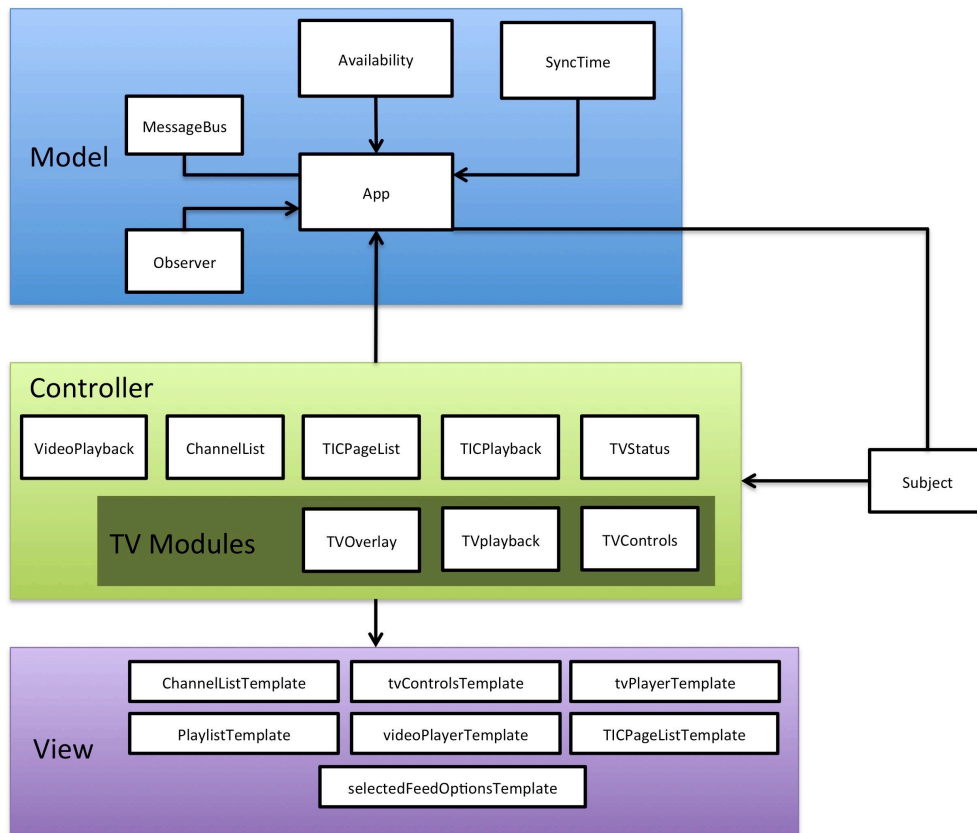


Image A - 1 Multiscreen platform architecture overview

## PLATFORM MESSAGING PROTOCOL

Application instances and the server communicate using a message bus, this replaces the long polling techniques used by the Olympic Companion application with a more robust and scalable method of communication. A proprietary message bus, Apache Apollo (Apollo, 2014), is used to broker transmission between components. Platform specific messages are wrapped in the Simple text orientated messaging protocol (abbreviated to STOMP) (STOMP, 2012) that defines client connection and disconnection (to the message bus not the applications server), and message routing. Apollo was chosen as it allows connection natively over web sockets to the web based clients of the application, however Apollo could be replaced with any future product, supporting web sockets and STOMP, and function identically. The following table outlines the message types used by the platform and how they enable the core functionality utilised by the MarathOn Multiscreen Application. The communication messages are transmitted across the

message bus, in the body section of the STOMP frame, they are encoded in JSON.

Message Type	Description	Example
newConnection	A request from the client to the server to connect. Upon a successful request the server responds with the data message. The connection request also includes the device type either app or television.	<pre>{"type":"connection", "connectionType": "newConnection", "deviceType":"app"}</pre>
connectionAccept	Response to the server to a connection request, includes a unique identifier for the client and the channel schema for the application to use. Further communication from the client utilises the identifier, so the sever knows how to deal with communication from each client, for example if the client is registered as a television, it updates the servers internal model of television playheads. Additionally all messages include a timestamp, therefore logs have temporal information and nodes can interpret the order of messages correctly.	<pre>{"type":"connectionAccept", "deviceId":1416494176508, "data":{"app":[{"...}]}, "timestamp":1416493965553}</pre>
Disconnection	A request from the client to the server to disconnect.	<pre>{"type":"connection", "connectionType": "disconnect", "deviceId":1416494176184, "deviceType":"tv"}</pre>
Ready	A simple internal message not sent across the message bus informing observing modules that the application and internal models has been setup based on the data received from the	<pre>"ready"</pre>

	server.	
StatusUpdate	User initiated changes to the applications state such as changing the channel or selecting a video feed. In the example opposite, the user has selected the professional video feed, which has the ID 'raceOverviewVideo' and the playback location is start. The progress field refers to any progress that the user has already made in the video stream, should the location be resume. In this case it is the first time the video has been played and the progress is set to 0.	{       "statusUpdate":{         "type":"feedSelect",         "device":"app",         "feedId":"raceOverviewVideo",         "progress":0,         "location":"start"},         "timestamp":1416494240901,         "deviceId":1416494176508}
PlayheadUpdate	Changes to the playhead state, such as fast forward, rewind and pause. Playhead time updates, raised by the HTML5 video time update method are generated approximately every 200ms, therefore to avoid unnecessary overhead are sent locally, to other observers but not sent across the message bus. This is indicated by the headOnly flag. Other application instances maintain their own playhead clock for the television, responsive to other playheadUpdates and occasional sync updates every 10 seconds. The state field indicates if the video player is paused or playing back and the seeker flag is set to true when the user has fast forwarded or rewound the video feed.	{       "playheadUpdate":{         "headOnly":false,         "feedId":"raceOverviewVideo",         "progress":5.525578,         "state":"paused",         "seeked":false,         "eventsViewed":[],         "timestamp":1416494247194,         "deviceId":1416494176508}
App	The app message type is left for application specific messages. For example, in the MarathOn	Add new tag {         "app":{           "type":"newTag",           "tag":{             "distance":9412,             "id":"14

	<p>Multiscreen, the first example opposite adds a new tag to the RunSpotRun dataset, including the tags location along the course (calculated from the latitude and longitude), the runners bib number, the time in the video and identifiers for the spectator and video.</p>	<pre>16494558647454", "latitude":52.9332544804400 56,"longitude":- 1.20449899647435,"raceNo": "1134", "spectatorID":"dcb42e4e- 7196-4d11-837a- 9b8aac8a3e8c", "time":1380445760.680195," videoID":"896c3537-c43b- 4ed2-a804- d2f1c58fbefc"}}, "timestamp":1 416494347362,"deviceId":14 16494176508}  Add video to playlist: {"app":{"type":"update", "playlist":[{"feedId":"spectatorp 9Video", "startTime":1433,"endTime":1 483,"playlistId":"1416494616 3710", "thumbnail":"http://192.168.0. 2/multiscreenWebappMaratho n/imgs/thumbs/p9Video.png", "feedName":"spectator 9 videos"}]}, "timestamp":141649 4405086,"deviceId":1416494 176508}</pre>
--	--	--

Table A - 1 Multiscreen platform message types

## MODULES

The following table outlines the modules implemented by the multiscreen platform and those implemented specifically for the MarathOn Multiscreen Application.

Server Core Modules	
Module Name	Module Description
Connection	Handle incoming connections and disconnections from clients, including distributing the channel schema.
Logging	Log user interactions from the message bus into a persistent file.



main	Main module which kicks off the server and handles loading in of persistent channel schema defined by a command line argument.
tvPlaybackState	Maintain the playback status of each channel for the television client.
MarathOn Multiscreen Server Modules	
playlistServer	Maintains the state of the playlist as an ordered array of videos.
Core Modules	
App	<p>The application module stores the application and instance models. It is also responsible for providing other modules safe access to the models and implements the subject for the observer pattern.</p> <p>In addition the app module is the entry point for the application and kick start connection to the message bus.</p>
Availability	The availability module determines which channels and feeds are available to users at any given time during the clients execution. Therefore feeds which have a start time and end time set are only available to users at the appropriate time.
ChannelList	Controller module that handles display and interaction with the channel list and feed selection.
MessageBus	Interface between the Message bus, the client and server. This module handles connection and disconnection to the message bus and server, and passes incoming messages to the application module and outgoing messages to the bus.
Observer	Handles subscription and unsubscription of modules to the subject (application module), publishes messages to subscribing modules.
SyncTime	The SyncTime module provides a synced time with the server, so playhead calculations of other clients are accurate. The syncTime is calculated by requesting a time from the server at the start of the clients execution and adjusting for network latency. All subsequent requests for a time value are calculated as a delta from the requested server time.
TICPageList	Enumerate the HTML pages available in an interactive feed and handle user interaction by issuing a playheadUpdate message to the observer subject to be handled by the TICPlayback module.

TICPlayback	Controller module that displays the selected interactive feed page.
TVControls	Controller module that displays the TV controls on an application client and handles user interaction with them, issuing playhead update messages to be sent across the bus.
TVOverlay	Module to handle the display of information overlays on the television client, such as pause notifications and channel changes.
TVPlayback	Responds to user interactions on application clients to playback and control the playback of video feeds on the television.
TVStatus	The TVstatus module is used by clients operating in application mode. The module maintains the playhead status of a TV client.
VideoPlayback	Controller module which handles playback and user interaction of video feeds on application clients.
MarathOn Multiscreen Modules	
eventPlaybackButton	Handler for buttons that allow for the playback of a single event, such as a runner appearing in a video, the video ID, and the playhead locations for the start and end of playback are encoded in the buttons ID. This module extracts the values from the ID and tells the message bus to playback video from start to end playheads
RunnerMap	Controller module which displays and handles interaction with the runner map view.
marathonHelpers	<p>A series of helper functions specific to functionality implemented by the MarathOn Multiscreen Application. Including</p> <p>Get videos that a particular runner is either in or is possibly in. This is calculated by a runners speed between two known points, either the start or end of the race, or other video tags, and cross referencing with the time each video was taken.</p> <p>Get and set methods for the RunSpotRun data file.</p> <p>A playback dialog, allowing users to select whether to watch a short clip of the runner on either the television or the tablet, or to add it to the playlist.</p>

taggingInterface	Controller module for a interactive feed page from which users can tag runners on the television.
PlaylistAddButton	Controller module, which handles user interaction with a button which adds videos to the playlist. playlist buttons are implemented by assigning a button or div control the class name 'addToPlyalistButton'
Playlist	Controller module to handle display and user interactions with the playlist interactive feed page.
RunnerList	Controller module which displays and handles interaction with the runner list view.
TabletTagOverlay	An overlay applied to applications clients video playback display that implements a runner tag button.

Table A - 2 Multiscreen platform messages

# Appendix B

## *Channel Schemas*

### OLYMPIC COMPANION APPLICATION

```
[{
  "title": "Atheletics",
  "loc": "http://192.168.0.2/videos/trialAthletic
s.m4v",
  "thumb":
"http://192.168.0.2/olympics/server/videos/thumbs/e
nnis.jpg",
  "land":
"http://192.168.0.2/olympics/server/pages/athletics
Land",
  "pages": "/var/www/olympics/server/pages/trialA
thleticsData.json",
  "beginTime" : 1,
  "endTime" : 4750000
},
{
  "title": "Rowing",
  "loc": "http://192.168.0.2/videos/trialRowing.m
4v",
  "thumb":
"http://192.168.0.2/olympics/server/videos/thumbs/r
owing.jpg",
```

```

        "land":
"http://192.168.0.2/olympics/server/pages/athletics
Land",
        "pages":
"/var/www/olympics/server/pages/trialRowingData.js
on",
        "beginTime" : 1200000,
        "endTime" : 2636000
    },
    {
        "title": "Cycling1",
        "loc": "http://192.168.0.2/videos/trialCycling.
m4v",
        "thumb":
"http://192.168.0.2/olympics/server/videos/thumbs/c
ycling.jpg",
        "land":
"http://192.168.0.2/olympics/server/pages/athletics
Land",
        "pages":
"/var/www/olympics/server/pages/trialCyclingData.js
on",
        "beginTime" : 1,
        "endTime" : 1257000
    },
    {
        "title": "Cycling2",
        "loc": "http://192.168.0.2/videos/trialCycling2
.m4v",
        "thumb":
"http://192.168.0.2/olympics/server/videos/thumbs/c
ycling.jpg",
        "land":
"http://192.168.0.2/olympics/server/pages/athletics
Land",
        "pages":
"/var/www/olympics/server/pages/trialCycling2Data.j
son",
        "beginTime" : 2100000,
        "endTime" : 3345000
    },
    {
        "title": "Tennis",
        "loc": "http://192.168.0.2/videos/trialTennis.m
4v",
        "thumb":
"http://192.168.0.2/olympics/server/videos/thumbs/t
ennis.jpg",

```

```

        "land":
"http://192.168.0.2/olympics/server/pages/athletics
Land",
        "pages":
"/var/www/olympics/server/pages/trialTennisData.jso
n",
        "beginTime" : 1800000,
        "endTime" : 2909000
    }
]

```

## MARATHON MULTISCREEN MODE 1

```

[
  {
    "channelName": "Race Overview",
    "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/marathumb.jpg",
    "startTime": 0,
    "channelId": "raceOverviewChannel",
    "visible": true,
    "endTime": 1911,
    "feeds": [
      {
        "type": "video",
        "feedId": "raceOverviewVideo",
        "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/marathumb.jpg",
        "visible": true,
        "description": "Watch the runners head out from
the start and the elite runners race. Also watch
the runners approach the finish line and complete
the challenge",
        "feedName": "Video: Race Overview",
        "startTime": 0,
        "endTime": 0,
        "videoList": [
          {
            "url":
"http://192.168.0.2/videos/raceOverview.m4v",
            "startTime": "0",
            "endTime": 1911,
            "eventList": []
          }
        ]
      }
    ]
  },

```

```

    "autoplay": {
      "tv": "no",
      "app": "no"
    }
  },
  {
    "type": "TIC",
    "feedId": "raceOverviewTIC",
    "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/info.jpg",
    "visible": true,
    "description": "Check out facts about marathons
and Nottingham's Robin Hood Marathon and Half
Marathon",
    "feedName": "Marathon Facts and Figures",
    "startTime": 0,
    "endTime": 0,
    "linkedToVideo": "raceOverviewVideo",
    "spoilerLock": false,
    "scrubber": false,
    "pageListDisplay": true,
    "pageList": [
      {
        "title": "Race Route",
        "pageId": "ProPage1",
        "time": 30,
        "displayAuto": false,
        "eventListId": 0,
        "custom": {},
        "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/route.txt"
      },
      {
        "title": "Wheelchair Race",
        "pageId": "ProPage2",
        "time": 215,
        "displayAuto": false,
        "eventListId": 0,
        "custom": {},
        "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/wheelchairStart.txt"
      },
      {
        "title": "Race History",
        "pageId": "ProPage3",

```

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    "time": 350,
    "displayAuto": false,
    "eventListId": 0,
    "custom": {},
    "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/nottRaceOverview.txt"
  },
  {
    "title": "Marathon Facts",
    "pageId": "ProPage5",
    "time": 420,
    "displayAuto": false,
    "eventListId": 0,
    "custom": {},
    "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/marathonFacts.txt"
  },
  {
    "title": "Marathon Origins",
    "pageId": "ProPage8",
    "time": 490,
    "displayAuto": false,
    "eventListId": 0,
    "custom": {},
    "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/origin.txt"
  },
  {
    "title": "Men's result",
    "pageId": "ProPage6",
    "time": 577,
    "displayAuto": false,
    "eventListId": 0,
    "custom": {},
    "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/mensResults.txt"
  },
  {
    "title": "Women's result",
    "pageId": "ProPage7",
    "time": 700,
    "displayAuto": false,
    "eventListId": 0,
    "custom": {},

```



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    "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/womensResults.txt"
    },
    {
      "title": "Robin Hood WR",
      "pageId": "ProPage4",
      "time": 93,
      "displayAuto": false,
      "eventListId": 0,
      "custom": {},
      "url":
"http://192.168.0.2/multiscreenWebappMarathon/pages
/robinhood.txt"
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
"autoSelect": false
},
{
  "channelName": "My Videos",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/myVideos.jpg",
  "visible": true,
  "startTime": 0,
  "channelId": "myVideosChannel",
  "endTime": 0,
  "feeds": [
    {
      "type": "video",
      "feedId": "spectatorp2Video",
      "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p2Video.png",
      "visible": true,
      "description": "Watch all the videos from
spectator2, who watched the race from university
park.",
      "feedName": "spectatorp2 videos",
      "custom": {

    },

```

```

    "startTime": 20,
    "endTime": 754,
    "videoList": [
      {
        "url":
"http://192.168.0.2/videos/spectatorVideos/p2Video.
mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
      }
    ],
    "autoplay": {
      "tv": "no",
      "app": "no"
    }
  },
  {
    "type": "video",
    "feedId": "spectatorp3Video",
    "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p3Video.png",
    "visible": true,
    "description": "Watch all the videos from
spectator3, who watched the race from University
park.",
    "feedName": "spectatorp3 videos",
    "startTime": 20,
    "endTime": 754,
    "custom": {

    },
    "videoList": [
      {
        "url":
"http://192.168.0.2/videos/spectatorVideos/p3Video.
mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
      }
    ],
    "autoplay": {
      "tv": "no",
      "app": "no"
    }
  },

```

```

{
  "type": "video",
  "feedId": "spectatorp5Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p5Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator5, who watched the race from the corner of
Beacon Road and Queen's Road East in Beeston.",
  "feedName": "spectatorp5 videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

    },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p5Video.
mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp6Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p6Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator6, who watched the race from the corner of
Beacon Road and Queen's Road East in Beeston.",
  "feedName": "spectatorp6 videos",
  "startTime": 20,
  "custom": {

    },
  "endTime": 754,
  "videoList": [

```

```

    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p6Video.
mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp7Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p7Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator7, who watched the race from Castle
Boulevard.",
  "feedName": "spectatorp7 Videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

  },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p7Video.
mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp8Video",

```

```

    "thumbNail":
    "http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p8Video.png",
    "visible": true,
    "description": "Watch all the videos from
spectator8, who watched the race from University
Park and surrounding area.",
    "feedName": "spectatorp8 videos",
    "startTime": 20,
    "endTime": 754,
    "custom": {

    },
    "videoList": [
    {
        "url":
"http://192.168.0.2/videos/spectatorVideos/p8Video.
mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
    }
    ],
    "autoplay": {
        "tv": "no",
        "app": "no"
    }
    },
    {
        "type": "video",
        "feedId": "spectatorp9Video",
        "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p9Video.png",
        "visible": true,
        "description": "Watch all the videos from
spectator9, who watched the race from University
Park",
        "feedName": "spectatorp9 videos",
        "startTime": 20,
        "endTime": 754,
        "custom": {

        },
        "videoList": [
        {

```

```

    "url":
    "http://192.168.0.2/videos/spectatorVideos/p9Video.
mp4",
    "startTime": "0",
    "endTime": 754,
    "eventList": []
  }
],
"autoplay": {
  "tv": "no",
  "app": "no"
},
{
  "type": "video",
  "feedId": "spectatorp11Video",
  "thumbnail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p11Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator11 who watched the race from near
Nottingham Station, Castle Boulevard and the finish
line.",
  "feedName": "spectatorp11 videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

  },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p11Video
.mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp12Video",

```

```

    "thumbNail":
    "http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p12Video.png",
    "visible": true,
    "description": "Watch all the videos from
spectator12, who watched the race from near
Nottingham Station and the finish line.",
    "feedName": "spectatorp12 videos",
    "startTime": 20,
    "endTime": 754,
    "custom": {

    },
    "videoList": [
    {
        "url":
"http://192.168.0.2/videos/spectatorVideos/p12Video
.mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
    }
    ],
    "autoplay": {
        "tv": "no",
        "app": "no"
    }
    },
    {
        "type": "video",
        "feedId": "spectatorp13Video",
        "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p13Video.png",
        "visible": true,
        "description": "Watch all the videos from
spectator13, who watched the race from University
Park",
        "feedName": "spectatorp13 videos",
        "startTime": 20,
        "endTime": 754,
        "custom": {

        },
        "videoList": [
        {

```

```

    "url":
"http://192.168.0.2/videos/spectatorVideos/p13Video
.mp4",
    "startTime": "0",
    "endTime": 754,
    "eventList": []
  }
],
"autoplay": {
  "tv": "no",
  "app": "no"
},
{
  "type": "video",
  "feedId": "spectatorp15Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p15Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator15, who watched the race from Castle
Boulevard and the finish line.",
  "feedName": "spectatorp15 videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

  },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p15Video
.mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp16Video",

```



```

    "thumbNail":
    "http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/pl6Video.png",
    "visible": true,
    "description": "Watch all the videos from
spectator16, who watched the race from University
Park.",
    "feedName": "spectatorp16 videos",
    "startTime": 20,
    "endTime": 754,
    "custom": {

    },
    "videoList": [
    {
        "url":
"http://192.168.0.2/videos/spectatorVideos/pl6Video
.mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
    }
    ],
    "autoplay": {
        "tv": "no",
        "app": "no"
    }
    },
    {
        "type": "video",
        "feedId": "spectatorp17Video",
        "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/pl7Video.png",
        "visible": true,
        "description": "Watch all the videos from
spectator17, who watched the race from castle
Boulevard.",
        "feedName": "spectatorp17 videos",
        "startTime": 20,
        "endTime": 754,
        "custom": {

        },
        "videoList": [
        {

```

```

    "url":
"http://192.168.0.2/videos/spectatorVideos/p17Video
.mp4",
    "startTime": "0",
    "endTime": 754,
    "eventList": []
  }
],
"autoplay": {
  "tv": "no",
  "app": "no"
},
{
  "type": "video",
  "feedId": "spectatorp18Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p18Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator18, who watched the race from the start
and finish lines.",
  "feedName": "spectatorp18 videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

  },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p18Video
.mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
{
  "type": "video",
  "feedId": "spectatorp19Video",

```

```

    "thumbNail":
    "http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p19Video.png",
    "visible": true,
    "description": "Watch all the videos from
spectator19, who watched the race from castle
Boulevard and the approach to the finish line.",
    "feedName": "spectatorp19 videos",
    "startTime": 20,
    "endTime": 754,
    "custom": {

    },
    "videoList": [
    {
        "url":
"http://192.168.0.2/videos/spectatorVideos/p19Video
.mp4",
        "startTime": "0",
        "endTime": 754,
        "eventList": []
    }
    ],
    "autoplay": {
        "tv": "no",
        "app": "no"
    }
    },
    {
        "type": "video",
        "feedId": "spectatorp20Video",
        "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p20Video.png",
        "visible": true,
        "description": "Watch all the videos from
spectator20, who watched the race from the start
line and the approach to the finish.",
        "feedName": "spectatorp20 videos",
        "startTime": 20,
        "endTime": 754,
        "custom": {

        },
        "videoList": [
        {

```

```

    "url":
"http://192.168.0.2/videos/spectatorVideos/p20Video
.mp4",
    "startTime": "0",
    "endTime": 754,
    "eventList": []
  }
],
"autoplay": {
  "tv": "no",
  "app": "no"
},
{
  "type": "video",
  "feedId": "spectatorp21Video",
  "thumbNail":
"http://192.168.0.2/multiscreenWebappMarathon/imgs/
thumbs/p21Video.png",
  "visible": true,
  "description": "Watch all the videos from
spectator21, who watched the race from University
Park",
  "feedName": "spectatorp21 Videos",
  "startTime": 20,
  "endTime": 754,
  "custom": {

  },
  "videoList": [
    {
      "url":
"http://192.168.0.2/videos/spectatorVideos/p21Video
.mp4",
      "startTime": "0",
      "endTime": 754,
      "eventList": []
    }
  ],
  "autoplay": {
    "tv": "no",
    "app": "no"
  }
},
"autoSelect": false
}
]

```